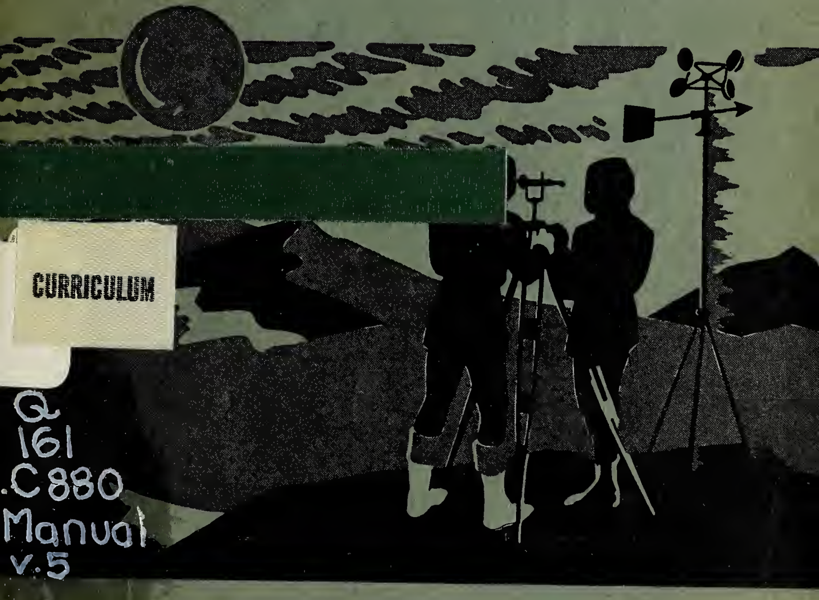
TEACHERS' MANUAL FOR

Working with Science

CRAIG AND HILL



OUR WORLD OF SCIENCE

CONTENTS

TEACHERS' MANUAL FOR *Working with Science*

FOREWORD: OUR WORLD OF SCIENCE

"It is no longer possible for us to ignore science in the elementary school if we are to discharge our full responsibilities as teachers," a superintendent of schools said recently to his teachers. In these words he expressed the view of thousands of parents in the United States who have become convinced of the great power of science in this modern world.

Unquestionably teachers in the elementary schools wish to meet the growing demand for science. But many of them are hesitant about teaching science because they recognize a weakness in their own background. The basal books in the series OUR WORLD OF SCIENCE and the accompanying Manuals have been written to meet the needs of classroom teachers, whether they have had previous training in science or not. The program of science presented in this series is one in which teachers can learn science with their pupils.

Reasons for Teaching Science

A moment's reflection is sufficient to indicate that there is no part of the elementary-school curriculum that has more important contributions to make to the present and future welfare of the nation and of the world than has science. In the following paragraphs are discussed briefly a few of these contributions.

Science makes it possible to abolish poverty. Geologists have learned a great deal recently about how to explore the earth for basic material resources. In cases where raw materials for some substances are scarce, chemists have learned ways of making synthetics which will serve all the purposes required of the original substances. This is illustrated in the manufacture of synthetic tires and quinine, for example. Chemists strive to make new substances from raw materials that are found in abundance, such

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as clay, farm produce, and coal tar, thus providing new substances at a very low cost. In this way industry is promoted, more people are given employment, and the new materials are made available to increasing numbers of people. Will the children in our classrooms be prepared to utilize wisely the great material resources of the earth?

Science makes it possible for us to eliminate backbreaking toil. A few years ago most of the work of the world was done with muscular energy. Today we have learned to harness vast stores of energy to machines that may be operated by the pressing of a button. These laborsaving devices can be used in our homes, in factories, and on the farm. Tasks which took hours or days to accomplish can now be completed in a simple operation, and thus more hours are provided for recreation. Will our children be equipped to make intelligent adjustment to the vast supplies of energy and new laborsaving inventions which are daily being made available?

Science makes it increasingly possible to improve the health and safety of the peoples of the world. One of the tasks of the children in our classrooms will be to see that the discoveries of the scientist make a life of good health and freedom from accident available to all.

Science makes it possible for hunger to be abolished. Many authorities contend that an ample supply of food can be raised for all the people of the world by using the improved methods of agriculture which have been discovered in recent years. There is, however, a grave danger that humanity will face increasing periods of famine if it does not soon learn to save its great soil resources. Will our children have the vision to plan for an ample world food supply, or will they through ignorance cause new periods of famine?

Everywhere we turn we see science offering to humanity a higher standard of living in the form of improved food, supply, recreation, transportation, communication, and health for all. This improvement, secured on a world-wide basis, would eliminate the chief causes of rivalry between nations and would help to promote permanent world peace.

The United States, as a result of recent events, has assumed a unique responsibility for world leadership. American children must be encouraged to have high ideals of service to humanity, and they must know how to put their ideals into operation on a democratic basis. They must be made to realize the responsibilities and opportunities that are theirs because they are Americans. They must discover while they are young the importance of science and must learn how it can be used to promote world welfare.

The record of the past indicates many fatal errors. Depressions, wars, destruction of valuable soils, pollution of streams and waterways, wastage of mineral resources, introduction of crop pests, have left their mark. With them have come needless poverty and ill health. The elementary school today is responsible for the development of a generation that will be wiser than past generations. Children must learn to realize the power that man has secured through science for the development of a civilization superior to their own.

The task, then, of the elementary teacher in teaching science is clear. Failure on her part to open up the avenues of science to the natural drives of children may result in citizens of tomorrow who are poorly prepared for the adjustments and responsibilities of the atomic age.

The Use of Books in the Teaching of Science

As much as possible the teacher should work with the children while they work, read with them while they read, discuss matters when they discuss them. In other words, the teacher should be a member of the group, learning with the children in a natural situation instead of watching their activities as a bystander or outsider. In all this work the basal book in science can lead to dynamic motivation and vitality of instruction.

The Development of an Informal Working Situation. An informal working situation in teaching science brings good results. It provides an opportunity for children to express their own ideas and to develop lines of interest.

This need not be interpreted, however, as a loose and undisciplined procedure. Science in itself has its discipline, which grows out of the scientific method and attitudes, and the teacher[1] should be keenly aware of the relation of method and attitudes to desirable social behavior in children. If this awareness is applied in science teaching, the teachers of a school should discover, in the work from the first grade through the eighth, a marked improvement in the ability of children to work together on problems.

In the teaching of science both teacher and children should feel relaxed. Much of the austerity found in American classrooms grows out of pressure and haste, which are not in keeping with the rhythm and tempo of child life. If the teacher will remember that the very nature of science calls for discovery and open-mindedness, she will lose the fear of admitting an error in her own thinking. She need have no reluctance in stating frankly that she is learning with her pupils and that there are many things she does not know. The true scientist is learning when he is making discoveries.

Reading in Science Teaching. Reading in the science book should lead to other types of activities, such as discussion, performing an experiment, and planning a science excursion. These activities in turn will cause the children and teacher to go back to the basal book or to supplementary material for information and for new interests and subjects. Many teachers find oral reading useful in science teaching.

As much time as is needed should be taken to clear up each thought. The teacher should allow the child to work important ideas found in the basal books into his thinking through the use of such basic drives as curiosity, imagination, and manipulation. The use of children's natural drives need not place the teacher in an embarrassing position, since in an informal teaching situation children can help one another.

It should be noted that this kind of work does not call for rapid reading. In fact, it may mean slow reading, with much

[1]Gerald S. Craig, *Science for the Elementary-School Teacher*, pp. 13–19, 30–36. Ginn and Company, Boston, 1940.

consideration of a single sentence, paragraph, or page, and the relating of content to the children's observations and experiences. The way in which children should use books in science is quite different from the way in which they read a book of fiction, such as a storybook. In science one is seeking truth, and truth is not secured through superficial reading.

Discussion and the Use of Basal Books. Discussion in science can grow out of the use of books. A child or the teacher may have a question about something that has been read. There may be an incident which a child or the teacher wants to add to illustrate a point. Someone may attempt to explain a statement or to add more content to make a point clear. Another may propose the making of a sketch or other art work to illustrate a point. In all this, books will serve to stimulate discussion. Basal science books will be useful also in checking the accuracy of the discussion.

A discussion may last only a few minutes, or it may profitably continue for some time. Teachers should strive toward the improvement of discussion; with younger children discussion is fragmentary and impulsive; with older children it may be characterized by high qualities of critical-mindedness and intelligent planning. Children can secure no small training in learning to discern the difference between reliable and unreliable information as a result of science education in the elementary school.

In teaching science we are concerned primarily with how to find the truth. The process of finding the truth is one that the teacher must share with the children. An authoritative book in the hands of a child serves to assist both him and the teacher in discovering the truth. The teacher should ask from time to time such questions as these: "How can we find out? Are you sure? How can we get the answer? Can you prove it? Why do you say that? How much of what you said is true? What does it mean to you?" It is to be noted that the teacher's primary task is not to answer questions but to help the children find the solution.

Experiments and the Use of Basal Books. Children in the elementary school should become aware of the meaning of experi-

mentation. Our World of Science is filled with suggestions of experiments which can safely be performed by children with equipment that can be obtained in any community. An experiment should be seen as something more than a funny trick or magic. Attention should be focused on what the experiment is to prove. Discussion forms an important part of experimentation in science. It is frequently wise to repeat experiments. Finally, the conclusions developed through the use of experiments should be checked with authoritative books whenever possible.

Field Excursions and the Use of Basal Books. At all times the content of the book should be closely related to what is going on in the community. One means is the field excursion. A field excursion may be short or long, depending on its purpose and the locality to be visited. Sometimes a trip may be made to the heating plant in the school basement, to the fuse box, to a fire extinguisher in a near-by hall, to some vantage point to observe the change of seasons, or to a suitable place to observe the clouds and weather changes. It frequently is advisable to make a trip again after an interval in order to note changes. This is particularly true in studying seasonal changes or the procession of weather changes.

Vacant lots, quarries, gravel pits, road cuts, plowed fields, meadows, woods, orchards, barnyards, are particularly good places for observation. The study of construction work, such as that of new buildings or new highways, power lines or telephone lines, provides opportunity for observation for children at all levels. Then, too, the work of the custodian or janitor of a school building has its scientific aspects, which give children opportunity for useful observation. How the various services, such as water, gas, telephone, electric power, enter a building is usually fascinating to children. In this work the janitor can be of valuable assistance to the teacher and children.

Children may need to collect material on a field excursion. This should be done only with a sensible view of conservation in mind. One of the most important meanings of science is the wise utilization of materials—conservation. Plants and animals

should not be brought into the classroom unless they are to be studied and cared for properly.

It is not necessary that the teacher be able to identify the various plants and animals by name in order to conduct a successful excursion. Many good field excursions have been conducted in the elementary school with only a minimum of identification. As a matter of fact, very few scientists or naturalists are capable of identifying exactly a wide range of objects.

New Challenges Needed from Time to Time. While emphasis has been placed on thoughtful rather than on rapid reading, the teacher should be on the alert to see that the work proceeds at a pace challenging to the children. One way to accomplish this is to move on to new aspects of the subject under consideration or to new subjects. A function of a good science book is to provide new, challenging, and vital subjects for children. Careful observation of the behavior of children will give the teacher indications of whether the children are ready for new material.

Science for All the Children

This discussion suggests how important it is that everyone in a democracy, whether scientist or layman, should have an understanding of the place of science in society. Science is a powerful tool which can be used for good or for evil. If democracy is to survive, the common people must become aware of the potentialities of modern science in a world community. To produce this awareness seems to be uniquely a task for the elementary school, since the elementary school is the school of the people. The teacher, then, will need to make certain that science is made to function in the thinking of all the children. In this way the elementary-school teacher becomes an important factor in the destiny of our nation and the world.

GERALD S. CRAIG

INTRODUCTION: WORKING WITH SCIENCE

The next few pages present some ideas on using science materials with ten-year-olds and eleven-year olds. Many of these ideas are not original. They are the contributions of children and teachers with whom I have worked in a good many different environments. In actual classroom situations they have been proved practical and workable.

Objectives in Terms of Child Development

Our aims in using science materials with children are in many ways the same as in teaching any subject matter. The outstanding attitudes which we hope children will gain because of any good learning situation are awareness, initiative, appreciation, clear thinking, and co-operation. In terms of the child's development these are the values we hold in mind for social studies or art experiences or music experiences. They are important values in teaching children, no matter what the subject matter may be.

The field of the natural sciences offers many opportunities for the building of these attitudes. Much of the subject matter of science lends itself to visual and tactual experiences. Many science situations are, in their nature, problem-solving. Furthermore, the problem in many instances may be set up and solved within a short period of time by one child or a group of children.

Because of such problem-solving situations, you will have a chance to observe individual children in their approach to the solution of a question. By so doing you may be able to guide them to better methods of attack and solution of their own problems. Some children are better able to express themselves freely in the field of science than in any other field. Such children should be given much freedom for investigation in this area of science.

Every child, however, is surrounded by the materials of science, and the child is himself a part of science. Therefore every child will find some phase of science which appeals to him, and some children will find much of it challenging. It is this aspect of real challenge which I urge you to capitalize. Personal challenge to each child is the basis of any worth-while learning situation.

How to Begin

In general it is better to begin the study of any particular area after the interest of the children has been thoroughly aroused. Such an interest may stem from the enthusiasm of a single child, or of a group of children, or from an enthusiasm of your own. Many times it is quite properly your place to suggest an area for investigation, since you probably have had wider and more varied experiences than any of the children in your group. You will be able to suggest the study of such problems as weather-forecasting, or why seasons change, or what makes an electric bell work. Such problems may not occur to children, but their interest in them may prove to be just as real as in problems proposed by themselves.

Let us suppose, however, that you wish your group to think through several possibilities and arrive at the selection of a problem for study. How may you stimulate group thinking?

Group Discussion. The most natural method is, of course, by group discussion. Children, as well as adults, need to talk of their ideas, of their personal interests. I have found group discussion a practical method for the selection of a problem for study.

The group should first understand that the period will be devoted to discussing possible science problems with a view toward selecting one problem for rather intensive investigation. Then it is a good plan to choose a secretary, who writes the suggestions on the board so that all may see them. Or you yourself may wish to act as the secretary so that discussion may proceed at full speed.

If you are the secretary, you may find that one of your hardest problems is to put down each suggestion exactly as it is given. If you edit the suggestion, you may lose something inherent in the original idea. A child's original statement often gives you valuable clues as to his correct ideas or his misconceptions.

As a suggestion comes from a child, he may elaborate the problem a bit. Others may add to his suggestion so that the entire group gains a fairly clear idea of the many interesting possibilities involved. You should not hesitate to offer your ideas too, for the teacher is a working member of the group.

After all contributions have been noted, they should be considered for possible grouping. For instance, such ideas as "Which are our harmful snakes?" "How do birds find their way?" and "How do squirrels find food in the winter?" might all be combined under the large topic "Some Interesting Animals and Some of Their Habits."

When the combined list has been completed, the group is ready for the final choice. Such a choice is important, I believe, and needs due consideration. It may be better, therefore, to delay the final choice a day or two in order to give the children a chance to think, read, and do a bit of talking about the topics. After such a period of time, the choice is made by the vote of the entire group.

Stimulating Group Thinking. It may be that your group is not yet ready for the choice of material in this manner. In that case you yourself should choose a topic which you think will lend itself to reading, experimenting, and discussion. You should then present this topic in as interesting a way as possible to your group. Children must be challenged if they are to derive any real and lasting benefit from the study of any subject. Your choice of a topic for study may be a good thing for your group just now. However, many teachers feel that it is wise to work toward group choice of a problem.

There are ways of stimulating ideas for group contribution. One young teacher who was introducing science materials for the first time to a group of ten-year-olds and eleven-year-olds found that the children were uncertain as to what topics they might suggest during the time set aside for science discussion. In order to clarify their ideas, she gathered as many science books as she could from the other groups in her building. These books were for the most part of fourth-grade and fifth-grade reading levels, but some were books for younger and some for older children. She spent a most enjoyable prediscussion period with her group in looking through these books for new ideas. At the end of this period of browsing, she was pleased to find that her children were full of suggestions. The ideas were contributed freely, and the group choice of a topic for study was made.

Out-of-Door Experiences. Another way to stimulate group thinking and discussion is through experience out of doors. You may have this general area in mind for science, but you may want the group to make the particular choice of a topic for investigation. In that case it is a good thing to take your group for a walk or a field trip. Before starting, it will be well to talk over the purpose of the expedition. The children should understand that they are to look for things about which they may wish to discover more information.

Such a walk or field trip does not need to be a long one. It may be a walk to a near-by pond or stream or meadow or wood, if you are fortunate enough to teach in such an environment. Or it may be a walk to a park. It may even be a walk to a vacant city lot.

One teacher with her group found some fascinating plants and animals in such a spot. Many of the plants were weeds, but the children discovered that weeds sometimes have lovely flowers. Many of the animals they found were insects. They were surprised at the number of different kinds. Then the children dug into the soil to study the roots of the plants. These they found to be interesting, but they were much more excited about the many, many crawling animals which they found in the soil.

Do not forget that you may take your walk on your own school grounds. You may need only to go outside the building to find a wealth of materials for possible study.

Many other trips may be taken in order to stimulate interest in possible study areas. Investigate your neighborhood. Is there a greenhouse near? Where is the telegraph office? Is the power plant close enough to be visited?

Group interest may also be aroused by pictures and by talks by adults or by other groups of children in your building.

Ways of Working

After the problem for study has been selected, the next question is "What shall we do now?" At this point it is well to bear in mind that two outstanding objectives in any learning situation are co-operation and individual initiative. This is a good place to

provide for the further development of these objectives in the process of planning. Your group is now ready to plan. It is ready to organize its questions for further research.

Planning. As before, the teacher or a child may act as chairman. The topic selected for study is thoroughly considered; questions are asked and written down for later organization and investigation. The children should understand that this is not the time for contributing answers to questions even though some may know the answers. This is the time to ask questions.

Questions, after they have all been recorded on the board before the class, are then considered for overlapping of thought. They are grouped and organized. Basic questions are to be investigated first. This is where the teacher is needed as a guide. She, with her wider experience and knowledge, can be a very real help in the organization of these questions.

Many teachers find it helpful to transfer this completed list of study questions to a large piece of paper which may be placed on the wall or on a bulletin board for easy reference. This list of questions is to be a guide for work. Other questions will arise as the work on the chosen topic progresses. Such questions may be added to those which have previously been listed.

But, again, some of you may say, "My group is not quite ready to choose a topic for study and to organize that topic for study." If this is true, I suggest that you develop their ability to plan. One way of doing this is as follows: Choose a chapter in *Working with Science* which you think will be of real interest to your group. Then let the children make a rapid examination of the chapter in order to discover the general area in which they will be working. Encourage them to look for the main ideas and to try to get the gist of each section. They might even make an outline of the chapter. Since the organization of the topics in each chapter of the book has grown out of many planning and working experiences with ten-year-olds and eleven-year-olds, the material is presented in a manner which is logical to children. In noting the organization, they may come to realize that much planning was done for them when the book was written. By becoming aware of

such planning, they may at a later date be more capable of doing their own planning.

Planning with children in the manner just described is good. It does help to work toward clear thinking and toward group co-operation. However, the element of initiative is sacrificed somewhat. Therefore I hope that you will work rapidly toward the group choice and planning of materials.

In whatever way the topic may have been chosen and organized, you are now ready to begin active investigation of that topic. There are several ways of investigating. First let us discuss reading in connection with investigation in science.

Reading. Reading is, of course, one way of gaining the ideas of others about certain questions. Ideas gained from others in this manner may be used in several ways. First they may be used to answer a question directly. This is reading for information, not merely reading about something. It is for this reason that I feel it is wise for children to have in mind the question to be answered or the problem to be solved before they begin to read.

Reading may be used as a check of ideas both spoken and written. Children often propose the solution to a problem. Such solutions cannot be verified by extended argument. One way to check such ideas is by reading. Again, this is reading for information. If there is any uncertainty about the child's proposed solution, it should be checked not in one book but in several. This is a step in sound thinking.

Reading may also offer suggestions for testing ideas by using concrete materials, by thinking or discussion, and by further reading. In other words, reading may be used for testing old ideas as well as for gaining new ones. Such a book as *Working with Science* provides opportunities for these varied types of reading.

Experimenting. *Working with Science* offers suggestions for many experiments. A better word to use is probably *experiences.* This is not merely a pedagogical distinction; it is a very real distinction. Most of the activities proposed in this book are not truly experiments. They are suggested experiences with simple materials. An experiment must be carefully controlled; it must be

carried out under known conditions so that the results will be accurate and so that they may be relied upon.

A word of caution may be in order here. If you can possibly do so, you yourself should carry out the experience beforehand, in order to see how it works and in order to check the results. This will make you feel more secure. Not that any of the described experiences are risky; they are all completely harmless. But checking the results of an experience is important. If you have worked it through previously, you will feel capable of acting as the checking authority. If you feel unsure of the results, you can check with someone who knows the answer or by further reading.

There are several ways for children to check the results of their experimenting, and they should always check. One way is to ask some available authority. Another way is to repeat the experience several times in order to determine whether the same results are obtained each time. Still another way of checking is by reading. The results of each experience proposed in this book are indicated either in the book itself or in this Manual.

This step of checking cannot be emphasized too much. It is a step which is inherent in the correct solution of any problem. It is one of those habits toward which you will want to lead your children. No matter what the experience may be, check it as carefully as you can.

May I make this plea? Do not let your children read about doing something, make a guess at the answer, and go on to something else. Help them to have the proposed experiences as well as other experiences which may occur to you or to them. Help them to check those experiences. Really work with science. You and your children will find new stimulation and enjoyment in your teaching and learning.

Observing. Some of the experiences which you will have with your children will be of another kind. These might be called observing experiences. Through them you can all work toward a keener awareness and a lasting appreciation of the things about you.

Observing experiences may take place in the classroom. A

small group of children may show what they have discovered to the larger group. The role of the larger group is that of a keen observer. If lantern slides or films are shown as one means of arriving at a solution to a problem, the role of the group is again that of a keen observer, not that of one waiting for entertainment. Or the group may act as observer during trips away from the schoolroom, such as those suggested on page 11.

Your group may have many kinds of observing experiences. It is your privilege to awaken in children a hunger for knowledge. Each child must be an active observer because his keen observations will be put to use in problem-solving.

Evaluation

After a part of the problem or the whole of it has been solved to the satisfaction of the entire group, including the teacher, you reach the interesting point of evaluation.

Most children enjoy evaluation because of the sheer joy of discovering how many facts they know. You consider the process of evaluation in terms of child development. You are interested in progress in individual problem attack and solution. You are interested in the development of initiative. You are interested in evidences of the appreciation of the work of others. Consequently you have a twofold problem of evaluation. The first is the evaluation of the acquisition of facts; the second is the evaluation of these more subtle factors in child development. The latter type of evaluation is, as you know, the more difficult of the two.

The child will be interested in a number of activities of the self-evaluation type. Objective tests of the true-false, matching, or completion variety are interesting to him. Examples of such tests are included in the following pages. Oral reports furnish another method of self-evaluation. Or children may wish to keep individual notebooks with illustrations as well as written explanations. These notebooks should be worked out according to the interests of the individual child. Then there are games, such as spelling bees using science words, or team games using questions prepared by the children. In addition there is the valuable evalua-

tion exercise of preparing a program for another group or for the assembly.

You will observe the individual's performance in such activities and use it as part of your evaluation of his work. In addition you will continually watch for evidences of his growing awareness of the things about him. Evidences will be found in his contributions to discussion, in his oral and written reports, in his painting and drawing. You will watch for progress in co-operation with others. You will be aware of the development of initiative. Individual problem attack will hold interest for you. Ability to make use of assimilated facts is important. You will keep in mind that the child should be showing more and more evidence of appreciation of his environment, including all the living things in it. And finally you will note to what degree each child is capable of thinking and of acting on that thinking.

KATHERINE E. HILL

I. THE NEAREST STAR

MEANINGS FOR CHILDREN

The goal for this chapter is to understand the following: Our sun is one of many, many suns, or stars. It is the nearest star to the earth. The sun is only a medium-sized star, but it is very large in comparison with the earth. The sun gives out light and heat because it is very hot. Other stars give out light and heat, too, because they are also very hot. The moon is not a source of light; it merely reflects light from the sun.

YOU MAY NEED TO KNOW

Our sun is the greatest single source of light and heat for the earth. It is one of millions of stars giving off light and heat. Many stars give off much more light and heat than the sun; some stars give off less light and heat. The sun seems to give off more light and heat than any other star because it is so much nearer to us. The sun is only about 93 million miles from the earth; the next nearest star, Proxima Centauri, is about 25 trillion miles away. All the other stars are out beyond this next nearest star.

The temperature of our sun at the surface is, we believe, about 10,000°F or 6000°C. The temperature of the interior of the sun is millions of degrees. The surface heat of the sun is measured by certain astronomical instruments which are believed to be quite accurate. Even though the sun is so hot, it is not burning with flames as a fire burns. Burning is a combination of a material with the gas oxygen. Rusting is slow burning. It is the combining of oxygen and iron. You know that a fire may be put out if it is smothered with sand or a blanket. When we smother a fire, we merely cut off the oxygen supply. Oxygen is not present in the proper amounts on the sun for burning as we know it. We say the sun is incandescent. It is hot without burning. Electric-light bulbs are often called incandescent bulbs. They are bright and hot. But they do not burn, because the oxygen has been removed from the bulb.

Stars are spheres of gaseous materials. Many of the elements found on the earth are also on the sun. Iron, sodium, hydrogen,

helium, and some sixty others of the nearly one hundred elements found on the earth are also present on the sun. However, the elements on the sun are all in a gaseous state. There are no solids or liquids on the sun; it is too hot. We do not really know why the sun continues to give off light and heat. Some scientists believe that the light and heat are due to the disintegration of atoms within the sun.

This sun of ours is a medium-sized sun. Some of the stars are smaller; others are much larger. The diameter of our sun is about 864,000 miles. Its diameter is about 109 times that of the earth. This means that the volume of the sun is tremendous as compared with the volume of the earth. The sun is so very large that over a million balls the size of the earth could be put inside the sun. Yet many stars are larger than the sun. Betelgeuse, one of the stars in the constellation Orion, is so large that if our sun could be put at its center, then Mercury, Venus, Earth, and Mars, with the proper distances between them, would fit within it.

But the sun gives off a great deal of light and heat and is quite near enough to us so that we receive a reasonable amount of both. We fortunately receive only about one two-billionth of the total light and heat of the sun. This is because the earth is so small in comparison with the sun that it intercepts a very small amount of the total light and heat.

Moonlight is reflected sunlight. The moon is not a source of light. We see the moon as we see one another. The moon reflects sunlight just as we reflect light to one another's eyes.

WAYS OF PROCEEDING

The material presented in these first pages of *Working with Science* should help children to observe more carefully and to discuss more effectively.

Introduction and Procedure. The material of this chapter could be used at any time during the year. There are many ways in which you may call the attention of your children to the sun. If it is autumn, you may help them to become aware that the sun is shining fewer and fewer minutes each day. In the spring the

reverse may be pointed out. You may raise the question "What would happen to us if there were no sun?" Or you may ask, "Which star is most important to us?" The answer to this question intrigues children. They do not often realize that our sun is a star. Of course the material in this chapter may be used if children raise their own question, "What is the sun?"

Use the picture on pages 4–5 for study. Talk about the picture. Only a small part of the sun is visible. How very large the sun is! The vast distance between the earth and the sun cannot be shown properly on this scale. The sun is very far away. Let the children read through page 6. Then have a lively discussion on sizes and distances of objects. Go out into the hall or out on the school ground. Let one child take a small object, such as a pin or a paper clip, and walk away from the group with it. How small the object seems now! Our large sun looks small because it is far away from us.

Study the picture on page 8 with your children and make the earth ball and the circle described in the text. Let them have a feeling of the hugeness of the sun. Studying the thermometers on pages 10 and 11 will help to develop an understanding of how hot a temperature of 10,000° must be. Let the children talk about heat and high temperatures which they have known.

Try out the reflection experiments suggested on page 13. Throughout the study of *Working with Science*, stop often as you read, and experiment. If you use the material only as a reading lesson, much of the point will be lost.

Material Needed. Some modeling clay; a small pocket mirror.

Something for You (p. 15). Allow the children to discuss possible changes, but direct their thinking to the following conclusions:

1. After the available fuel and food supplies had been used, there would be no life. Man cannot make and control heat and light energy.

2. A green plant needs light in order to manufacture food in the leaves. Any animal depends on green plants for food. Even car-

nivorous, or flesh-eating, animals are indirectly dependent upon green plants. Heat from the sun causes water to evaporate. Gravity pulls water down toward the center of the earth. A fire needs fuel. Coal was made from green plants. Trees grow because of sunlight.

Further Activities. 1. Draw a circle out of doors with a diameter of 54 inches. This represents the sun. Draw a $\frac{1}{2}$-inch circle at a distance of about 485 feet. This shows the proper relationship between the sun and the earth, both as to size and distance.

2. Put a healthy plant in a dark place for a few days. Water the plant daily. The leaves will soon begin to lose their color and the plant will die; it cannot make food without light.

3. Read about the sun and other stars in other books.

Evaluation. 1. For the child's personal satisfaction, let him draw a picture or write a story, or both, to show the importance of the sun to us or to show sun-earth size relationships.

2. Watch the contributions of individuals to discussions.

3. A class mural showing the importance of the sun to us might be made. Allow as many children as possible to contribute to this. Take note of the ideas of the individual children as they plan and execute this mural. It will help you to evaluate their progress.

4. Some children may wish to make an oral report of further findings in relation to this material.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

The words given below are important science words used in this chapter. Similar lists will be included for each of the following chapters. No attempt has been made to provide complete definitions. Only the meaning necessary for understanding any word as it is used in this text is given here.

Many of these science words are already familiar to your pupils. The new words should be developed naturally during discussion periods and should become a part of the vocabulary of each child. In so far as possible, meanings should be enriched far beyond a mere definition. This may be accomplished by reading, discussion, observation, and experimentation.

degree (dē grē'). A division, or space, marked on a thermometer.
gas. The state of a substance in which it holds no definite shape or volume of its own. Air is made up of such gases as nitrogen, oxygen, carbon dioxide, and water vapor.
mercury (mûr'kū rĭ). A heavy, silver-white metal which is liquid at ordinary temperatures. Mercury is used in some thermometers.
reflect (rē flĕct'). To bend or throw back. When an object throws back light which falls on it, the object is said to reflect light.
telescope (tĕl'ē skōp). An instrument which makes it possible to see far more stars and other very distant objects in the sky than we could see without it.
temperature (tĕm'pẽr *ȧ* tūr). The measure of heat of anything.

Key to Pronunciation

ā *as in* hāy	ê *as in* bêgin'	ô *as in* hôrse	oi *as in* boil
ȧ *as in* chȧot'ic	ĕ *as in* nĕt	ŏ *as in* tŏp	o͝o *as in* to͝ok
â *as in* dâre	*ĕ* *as in* si'lĕnt	ô *as in* sôft	o͞o *as in* mo͞on
ă *as in* căt	ẽ *as in* mak'ẽr	*ŏ* *as in* ŏccur'	ou *as in* out
ă *as in* in'fănt			ng *as in* sing
ä *as in* bärn	ī *as in* rīde	ū *as in* mūsic	th *as in* thin
ȧ *as in* grȧss	ĭ *as in* gĭft	ů *as in* for'můla	~~th~~ *as in* ~~th~~at
ȧ *as in* sofȧ	*ĭ* *as in* dĭrect'	û *as in* bûrn	tū *as in* na'tūre
		ŭ *as in* ŭp	dū *as in* ver'dūre
ē *as in* hē	ō *as in* jōke	*ŭ* *as in* cir'cŭs	N *as in* boN
ẹ *as in* hẹre	ȯ *as in* ȯbey'	ü *as in* menü'	zh *as z in* azure

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FILMS[2]

Solar Family*

[1]For addresses of publishers see page 82. [2]See page 83.
*Films so designated are somewhat advanced in comparison with the text, but may be useful for some groups.

II. HEAT CHANGES THINGS

MEANINGS FOR CHILDREN

The primary goal is, as the title suggests, to understand that heat causes things to change. Heat will change water to steam; heat will make water circulate. Some things, such as metals, conduct heat very well. Heat makes things expand. Heat from the sun warms the earth. The air around the earth does two things: (1) it keeps too much of the sun's heat from reaching us; and (2) it holds much of the sun's heat, which does get through the air, close to the earth. The warmed air warms our bodies.

YOU MAY NEED TO KNOW

Man cannot really make heat. But he has learned how to use heat. Heat from the sun is stored in various fuels. Man has learned to use these fuels.

Heat causes things to melt and to vaporize. The changing of a solid to a liquid is called melting. It is the opposite of freezing. Ice melts at 32°F. Other materials will not melt until they have reached a higher temperature. This is true of iron. Lead melts at a fairly low temperature, as does paraffin. However, any substance must be heated to make it melt. The changing of a liquid to a gas is called vaporization. Water will evaporate at room temperature. Boiling is merely rapid evaporation. Water boils at 212° F at sea level. Other substances, such as lead and iron, will also boil, but at higher temperatures. When water boils or when it evaporates at room temperature, liquid water changes to invisible water vapor. Water vapor is a gas. There are other invisible gases in the air. If air is cooled enough, it becomes a liquid.

Steam is water in a gaseous state. Steam is invisible. The white cloud you see over a pan of hot water is condensed water vapor. Condensed water vapor is made of many droplets of liquid water.

When anything is heated, the molecules, or small particles, of which that material is made begin to move more rapidly. If a liquid or gas is heated, the molecules move about rather freely. We say that the liquid or the gas circulates.

When a solid, such as a silver spoon, is heated, the molecules begin to vibrate more rapidly. Then we say the metal is hot. The molecules nearest the heat begin to vibrate first. Finally all the molecules are vibrating so that the whole silver spoon is hot. The spoon has conducted heat. Because of the vibration, the metal expands.

Heat from the sun warms the earth. Air is not a very good conductor of heat. But some heat from the sun does pass through the air to warm the earth. The earth reflects this heat. Then the air, because it is a poor conductor, holds the heat close to the earth. If air is fairly thin above the ground, as it is on mountaintops, more of this "earth heat" escapes. Therefore you feel cooler in the shade on mountaintops. On the other hand, if you stand in direct sunlight on a mountaintop, you are likely to feel very warm. This is because there is not enough air to shield you from the direct rays of the sun. So the air both protects and warms us.

WAYS OF PROCEEDING

The material in this chapter lends itself to much individual and group experimenting. A small oilcloth-covered table is a good kind to use as a science table. You may want to do some of the experiments with the entire group. In other instances you may want a committee to work out an experiment and present it to the remainder of the group. Or you may prefer to have an individual present the experiment. It is very important to make time somewhere in your program for repetition of an experiment either by the individual or by a small group. Many times the initial experiment needs to be repeated if the most is to be gained.

Introduction and Procedure. The study of this chapter may grow out of the discussion of the heat of the sun. However, it is not necessary to work on the materials in Chapter I before considering the question of heat. The experiences in this chapter may come out of cooking experiences. They may come from camping experiences with fire-building. If the question does not arise from the children, you may introduce it by calling attention to experiences with heat and asking how men used to build fires. The man

pictured on page 16 is using flint to strike a spark. Get a piece of flint and a piece of steel. Take your children out of doors and try to build a small fire by striking sparks with flint and steel.

Children like to experiment. Let them do the experiments described on pages 20–22. In order to experience the flat taste of boiled water, boil some water in a clean dish for at least twenty minutes. Let the children, using individual cups, taste boiled water and unboiled water. Then put air back into the boiled water as described. Do these experiments over if the children wish to. Or let them try the experiments during their free time. Performing the simple experiments described on pages 23–26 will further enrich and clarify the pupils' understanding of the effect of heat on water.

Help the children with the conduction-through-metal experiments on pages 26–29. Urge them to repeat such experiments at home and to look about them for as many examples as they can find of expansion due to heat. Have a discussion on this. In working on "Mountaintops and Heat," let the children recall as many experiences as they can about being on mountaintops. Then let them theorize as to why it is cold on mountaintops. Have them read for information and then discuss their findings. Here is a chance to read for checking of ideas.

Materials Needed. Electric hot plate (or Sterno set or other heating apparatus), Pyrex dish, fruit jar with cap, egg-beater, paper cups, a little sawdust, three spoons of different metals but the same size, small metal rod, pot-holder, candle wax or paraffin, room or outdoor thermometer, cooking thermometer.

Something for You (p. 37). 1. Cooking breaks down plant and animal tissues and makes the food more tender and sometimes more appetizing. Cooking also kills many disease organisms. We eat some foods raw because we enjoy the taste and because fewer of the vitamins are destroyed.

2. Lead, paraffin, and wax are other solids which can be easily melted.

3. The rubbing alcohol evaporates faster.

4. This exercise might lead to a good discussion on life in equatorial and polar regions.

Further Activities. 1. Build a small fire. Put it out with sand or dirt.

2. Discuss fire-prevention rules.

3. Let a Boy Scout or a Girl Scout make a fire with flint and steel or with the Indian fire drill.

4. Encourage children to think of other experiments showing some interesting facts about heat. Try them out.

Evaluation. Here is a true-false test for the children. Write the statements on the blackboard or have them hectographed. The statements are marked correctly.

(*T*) 1. The early settlers in this country used flint and steel to build fires.

(*T*) 2. Boiled water tastes flat because the air has been driven out.

(*F*) 3. The white cloud above a pan of boiling water is steam.

(*T*) 4. When water is being heated, the first small bubbles are air bubbles.

(*T*) 5. Air is a poor conductor of heat.

(*F*) 6. All metals conduct heat equally well.

(*F*) 7. When a solid is heated, it contracts.

(*T*) 8. It is often cold on mountaintops because there is not enough air above the mountaintop to hold the heat reflected from the earth.

In your evaluation of the individual's work, you will want to watch for growth in ease in handling materials. Note whether or not the child suggests further experiments and whether he does some of the experiments at home. Let your children plan a program on heat for another group or for an assembly. Be sure that each child has a chance to contribute.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

aluminum (*ȧ* lū'mĭ n*ŭ*m). A light silverlike metal.
atmosphere (ăt'm*ŏ*s fē̦r). All the air around the earth.
circulate (sûr'kū̇ lāt). To move around in such a way as to come back to the starting point.
condense (k*ŏ*n dĕns'). To come together into a smaller space.

conduct (kŏn dŭkt′). To be the means of sending heat or electricity from one place to another.

contract (kŏn trăct′). To come together in a smaller space; to shorten; to shrink.

dense air. Air that is not thin is said to be dense; that is, all the particles that make up its gases are crowded together.

dissolve (dĭ zŏlv′). To become a part of a liquid.

evaporate (ē văp′ō rāt). To change into a gas.

expand (ĕks pănd′). To spread out; to cause something to take up more space.

experiment (ĕks pĕr′ĭ mĕnt). A trial made to prove or disprove something.

flint. A very hard kind of quartz. Quartz is a mineral.

liquid. The state of a substance in which it holds no definite shape but does hold a definite volume. Water, oil, gasoline, and melted lead are liquids.

melt. To be changed from a solid to a liquid state, usually by heat.

solid. A substance which keeps its shape at ordinary temperatures.

steam. The invisible gas or vapor into which water is changed when it is heated to the boiling point. Steam is invisible.

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III. THE CHANGING SEASONS

MEANINGS FOR CHILDREN

The earth rotates on its axis, causing day and night. At the same time, the earth revolves about the sun. The axis of the earth is tilted. The north pole always points in the general direction of the North, or Pole, Star. Because the earth revolves about the sun and because the earth is always tilted at about the same angle, seasonal change occurs on the earth. Seasons change all over the earth, although in some places seasonal change is more spectacular than in others.

YOU MAY NEED TO KNOW

It is perhaps natural to assume that we have our coldest season when we are at a greater distance from the sun. This is not true. June is the month when the earth is farthest from the sun. The earth is more than a million miles nearer the sun in December. If we stop to think further, we know that the colder winter season could not be caused by greater distance from the sun. If this were true, the entire earth would have colder weather at the same time. The Southern Hemisphere has its coldest weather during June, July, and August. The Northern Hemisphere has its coldest weather during December, January, and February.

Seasonal change, then, is not caused by varying distance from the sun. It is the result of a combination of other factors. The earth is tilted so that its axis makes an angle of $23\frac{1}{2}°$ with a perpendicular line dropped to the plane of the earth's orbit. This angle is, for our purposes, constant. In addition, the earth revolves about the sun. Because of these two facts, the Northern Hemisphere receives a greater amount of sunlight during May, June, and July than at any other time of the year. The Southern Hemisphere, in turn, receives a greater amount of sunlight during November, December, and January. The illustrations on pages 42–51 will help to make these facts clear.

The sun's rays fall more or less perpendicularly on the equatorial regions during the entire year. The sun's rays fall more and

more perpendicularly on the Northern Hemisphere during May and June until, on June 21, they reach the Tropic of Cancer. Then, because the earth continues to move about the sun, the direct rays of the sun again pass over the equatorial regions and into the Southern Hemisphere. Finally, on December 21, the direct rays of the sun reach their farthest southern point, the Tropic of Capricorn.

Distance from the sun does not cause seasonal change, but it does affect the intensity of the seasons on the earth. The earth is nearest the sun during December. The Southern Hemisphere has its summer at that time and so has a more intense summer than it might otherwise have. Since the Northern Hemisphere has its winter when the earth is nearest the sun, it has a less intense winter than it might otherwise have. Because the earth is at its greatest distance from the sun during June, the Northern Hemisphere has a less intense summer than it might otherwise have.

WAYS OF PROCEEDING

This chapter may be used at any time during the year. It is not dependent for its meanings on any other chapter. The chapter attempts to help children to understand why the earth undergoes seasonal change.

Introduction and Procedure. This chapter might perhaps best be used in the fall or spring when children will most naturally begin to notice changes in air temperature, in hours of sunlight, and in plants and animals. They may bring up some such observation as the fact that the days are growing colder or that the robins are coming back. However, if they do not note such facts, you may call their attention to them. Ask them to look for evidences of seasonal change. Help them to notice that there are fewer or more daylight hours, as the case may be.

Then let the group theorize as to whether seasons are the same all over the earth. Use the pictures of summer days and winter days on pages 40 and 41 to help them to understand that summer temperatures are not the same in all places, and that winter tem-

peratures too are different in different places. Help them to understand that there is a greater temperature change from summer to winter in some regions than in others. Now let your group theorize as to why seasons change. They will probably answer in terms of distance of the earth from the sun. It is now time to do the experiments suggested on page 43 and following pages. Do not depend on the pictures, but do the experiments. These experiments should be done slowly with time for questions. You may find that you will need to repeat the experiments so that all children may understand the reasons for seasonal change. Vary the experiments by allowing different individuals to demonstrate why South America has its summer season in December and January. Only by working through this experiment a number of times will children really grasp the reasons for seasonal change.

Materials Needed. Earth globe, electric lamp or flashlight, chalk.

Something for You (p. 53). 1. You would live in the Northern Hemisphere from the beginning of November to the end of March and in the Southern Hemisphere from the beginning of April to the end of October.

2. The equatorial regions receive more light and heat the year round.

3. Keep this chart for about two weeks at any season of the year.

Further Activities. 1. If this material is used in the fall, use it again in the spring as a review and to compare results.

2. Make a list of evidences of seasonal change.

3. Keep a class notebook throughout the year. Each month enter a picture and written description of the season. Use this notebook in the spring for review.

Evaluation. 1. Allow individuals or small groups to work out their ideas concerning seasonal change. Watch for evidences of their understanding.

2. Give a test, allowing both pictures and words to be used. Give such topics as "Describe a December Day in Argentina" or "Describe March in Cuba."

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

arctic (ärk'tĭk). Of or having to do with the north pole or the region surrounding it.

axis (ăk'sĭs). The imaginary straight line from the north pole through the center of the earth to the south pole. The earth rotates upon its axis.

diameter (dī ăm'ḗ tẽr). The diameter of a circle is a straight line which passes from one side of the circle to the other through the center.

north pole. The northern end of the earth's axis.

North Star. The star toward which the northern end of the axis of the earth points.

season. One of the four divisions of the year: spring, summer, autumn, and winter.

seasonal. Coming at one of the seasons, or affected by the season.

south pole. The southern end of the earth's axis.

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FILMS

Play in the Snow — Earth in Motion* — Our Earth

*Films so designated are somewhat advanced in comparison with the text, but may be useful for some groups.

IV. PLANTS THROUGH THE SEASONS

MEANINGS FOR CHILDREN

Plants show changes from season to season. Some plants die in the winter. Before some plants die, they make seeds from which new plants grow in the spring.

Other kinds of plants grow from bulbs and roots. Buds are formed on plants in the summer or early fall. Some plants lose their leaves in the fall; other plants do not.

YOU MAY NEED TO KNOW

In the temperate and subarctic regions of the earth, many plants either die or lose their leaves in the fall. Scientists tell us that the general range of temperature which plants can endure and still make food and grow is from about 32°F to 122°F. Many of our garden flowers, crop plants, and weeds die in the fall but have produced seeds which will produce new plants in the spring or summer. Other plants die down to the ground level, but the roots or bulbs remain alive. New plants grow from these roots or bulbs in the spring or summer. Other plants live through the winter in a more or less resting state. Many of these plants, such as the deciduous trees, lose their leaves. Leaf buds and flower buds are formed in the summer or early autumn. In the spring these buds swell and burst. Next spring's buds may be found on a deciduous tree in the fall.

A deciduous tree loses its leaves after a separation layer has been formed. Before the separation layer is completely formed, the leaves often turn red or yellow. This is because the green coloring matter, chlorophyll, is no longer active in the leaf. The red and yellow coloring is in the leaf all summer, but it is obscured by the chlorophyll. Early in the spring, before the chlorophyll becomes active, the young leaves exhibit this same coloring.

Evergreens do not lose their leaves at any particular time of the year. There are leaves on the trees all year. Evergreen needles are shed at any time. However, evergreens are not active during the winter. Their greatest growth is in the spring. It is at this

time that we notice the new green growth, or candles, at the ends of some evergreen branches.

Seeds contain a young plant plus much stored food which may be used by the plant until the green leaves are able to manufacture food. Food is also stored around young plants in bulbs. New growth may also come from roots.

Seasonal change does noticeably affect plant growth in the colder regions of the earth. In the warmer regions, where there is no season of cold or drought, plants continue to grow during the various months. This is the reason for the lush growth of tropical regions.

WAYS OF PROCEEDING

This chapter is independent of other chapters, although it might logically precede or follow Chapter III, "The Changing Seasons," which discusses the reasons for seasonal change. This material could probably be used most effectively in the spring or in the fall, or at both times for comparison.

Introduction and Procedure. Many times children, if they feel free to do so, will bring milkweed seeds or cockleburs or fall leaves or fall flowers to school. This gives an excellent opportunity for beginning a study of changes which are taking place in plants. If your group needs stimulation, you might bring in some of these things. Urge children to add to the collection of seeds and flowers. You will need to caution them to collect only a few flowers or twigs. Be sure that they understand that such collections should be made with care so as not to injure a plant. In addition talk over with them the fact that they should secure the owner's permission to collect plants or twigs or flowers.

A thorough study of a collection of seeds will be interesting. Throw the seeds into the air to see how they float. If the wind is blowing hard, take some of the seeds out of doors and toss them into the air. Watch how they travel. Open some Lima-bean seeds, as is suggested on page 57. The young plant, shown in the picture of an opened seed, will be easy to see. Plant some of these seeds. Do the experiments with roots suggested on page 58. The plants

will make lovely winter decoration. Cut a bulb open and examine it, as is suggested on page 59. Plant narcissus bulbs in pebbles five or six weeks before Christmas. Leave them in a dark, cool place about two weeks or until the roots are strong. Be sure they have plenty of water.

Help children to collect branches of fruit trees or horse-chestnuts or maples or oaks for spring bouquets. Cut the small branches from the trees. Do not take too many from one place. Examine the branches for buds and for leaf scars. If you wish to force the buds, immerse them, top down, in warm water and leave them for several hours. This will hasten the opening of leaf and flower buds. Arrange the branches in a vase.

Again, make every effort to take your pupils out of doors to observe seasonal changes as often as you can.

Materials Needed. Dried Lima beans or dried peas, two or three carrots or turnips, a shallow plate, a few onions, vases.

Something for You (p. 67). 1. Plants need warmth and water for growth. They have these things all year long in hot countries. Young plants may be killed by a frost. If plants did not store food, we should have fewer plants. All animals, including man, are dependent on plant food.

2. Include an evergreen and an oak or maple if possible.

3. Keep a picture record.

4. The bulbs grow larger and larger. Food is made in the leaves above ground. These leaves finally die.

5. The buds are rounded and green.

Further Activities. 1. Make a mural of plants through the seasons.

2. Plan to take a walk over the same route at several different times during the year. Keep a written and pictorial record of the changes observed.

3. Ask a gardener or farmer if you may visit him to see how he prepares his garden or farm for winter. Make another visit in the spring.

Evaluation. Give a test to gain some idea of subject-matter learnings. You will also be aware, of course, of these points for evaluation:

1. Is the child taking an active part in group work?

2. Is the child able to express himself more easily than at first in his writing, speaking, and drawing?

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

bud. The part of a stem or twig where the new leaves and flowers are found. Buds usually open in the spring.

bulb. A vertical underground stem with scalelike leaves. Onions, lilies, and tulips grow from bulbs.

burdock (bûr′dŏk). A common plant easily recognized by the burs, which attach themselves to the wool or hides of animals, whereby the seeds are scattered far and wide.

evergreen. Any plant which has green leaves all year long.

leaf scar. A mark left on a stem after a leaf has fallen.

narcissus (när sĭs′ŭs). A kind of bulbous plant, including the daffodils and the jonquil.

plant. A vegetable, as distinguished from an animal.

produce (prō dūs′). To cause to be or to happen.

root (rōōt). The part of a plant, usually underground, which absorbs and stores food for the plant and helps to hold it in place.

seed. The small body produced by flowering plants from which new plants grow.

separation layer. A thin layer of cells which grows between the leaf and the stem in the late summer or early fall.

vein. A tube in a leaf which carries liquid.

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FILMS

Seed Dispersal — Gardening — Leaves

V. ANIMALS THROUGH THE SEASONS

MEANINGS FOR CHILDREN

Many animals show adaptation to seasonal change. The coats of some mammals grow thicker in the winter. Some insects undergo metamorphosis, or change of form. Some animals spend all or part of the winter in resting. Other animals migrate. Some animals store food for the winter.

YOU MAY NEED TO KNOW

Animals exhibit various methods of adaptation to seasonal change. So far as we know, these animals do not consciously adapt themselves; they become adapted through no conscious action of their own. Man does adapt himself consciously to seasonal change.

Animals with fur or feathers often have thicker coats during the colder months. The coloring often changes, too. Bright colors in the winter would make some animals easy prey for other animals. If an animal lives in a cold region, its winter coat is often white or dull in color. Insects such as butterflies and moths undergo metamorphosis. The resting, or pupal, stage often occurs during the colder months. During the pupal stage the insect may rest in a cocoon or chrysalis or in the ground.

Some animals migrate in the spring and fall. Many birds do this. The migration routes of some birds, such as the hummingbird, are very long. Birds migrate at different times of the day. In the spring the males often arrive before the females. Some birds do not migrate or else they migrate only very short distances. We call these birds permanent residents.

Fish such as salmon, eels, and shad also migrate. The adult fish migrate at spawning time. The young fish also migrate. Reindeer, polar bears, and seals migrate. They apparently migrate because of food and weather conditions.

No one really knows why animals migrate, although much research has been done on this question. Nor does anyone know how animals find their way back to the same place year after year.

Some animals hibernate. Many cold-blooded animals would die if they did not hibernate. The blood temperature of a cold-blooded animal varies with the temperature of the air or water around the animal. If the air or water were below the freezing point of water, the animal would freeze and die. Frogs, toads, turtles, and snakes are cold-blooded animals which hibernate. Some mammals hibernate all winter. Woodchucks do this. Before these animals go into hibernation, they eat a good deal of food. This food is stored as fat in the body of the animal and furnishes energy for it during the winter. Sometimes hibernating animals die.

Other mammals, such as chipmunks, opossums, skunks, and bats, are partial hibernators. On warm days these animals come out of hibernation and search for food.

Seasons, in the temperate and cold parts of the world, do affect animals. Some animals living in warmer parts of the earth rest during the warmest and driest parts of the year.

WAYS OF PROCEEDING

This chapter may be used alone or in conjunction with Chapter III, "The Changing Seasons," and Chapter IV, "Plants Through the Seasons." This is a chapter which will give you opportunity for observation, reading, and discussion.

Introduction and Procedure. This material may be used either in the fall or spring. Children very often notice the migrating birds at either season. In the spring they often notice caterpillars, and sometimes bring them to school. Use these opportunities to begin your work. If these things do not happen, begin your work by bringing in caterpillars if it is spring or by bringing in cocoons if it is fall. Call the attention of the children to the migrating birds at either season. Direct their attention to the coats of birds and mammals. Use the pictures and reading material on pages 68–71 as an introduction. In discussing the picture on page 69, ask the children to notice particularly how squirrels shed some of their heavy fur in the spring and regain it in the fall.

Children of this age often know a good deal about butterflies and moths. Try to help children to gain a thorough understanding of the metamorphosis of these insects. Note that the picture on page 72 shows monarch-butterfly eggs in their natural size. The eggs on page 73 are enlarged, but their sizes are correct in relation to one another. The caterpillars at the tops of pages 74 and 75 are not shown in their exact sizes, but their sizes are correct in relation to one another. This is also true of the cocoons and chrysalises at the bottom of pages 74 and 75. Keep cocoons in the classroom, as suggested on page 77.

After the children have named and observed migrating birds, let them theorize as to why birds migrate. Use pages 85 and 86 to check their theories. Read in other books about migrators.

Hibernation is also familiar to children. Let them discuss and read about hibernators as much as possible.

Something for You (p. 95). 1. Yes.

2. Yes.

3. Plant grass or grass seeds in the box. Water it often. Place a pan of water in the box for the animal.

4. Make this into a wall chart.

Further Activities. 1. Take as many walks out of doors as possible at different times to watch animals storing food, migrating, etc.

2. Make a series of pictures showing animals through the seasons.

3. Model animals of clay and paint them in their proper colors. Place them in a cut-away box or crate with proper background, grass, and trees to show their habitat.

Evaluation. Play a game somewhat similar to a spelling bee. Choose teams. Say "migrator" to a child. He must name a migrating animal. Use other words, such as "hibernator," "partial hibernator," "changes coat color," and so on. If a child misses, he sits down. Finally the winner will remain standing. This game will give you some idea of the subject-matter learnings, especially

if you play it several times. You will also want to be aware of individual progress in observing, discussing, and recording.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

banding birds. The practice of putting a light metal band on the leg of a bird as a means of studying the migrating habits of birds.

caterpillar. The second stage in the life of a butterfly or moth.

Cecropia (sē krō'pĭ *ȧ*) **moth.** A large silkworm moth.

chrysalis (krĭs'*ȧ* lĭs). A butterfly in its third, or resting, stage (pupa).

cocoon (kȯ ko͞on'). The silky shell, or case, spun by the caterpillars of some insects, especially moths. Moths spend the third stage of their lives in a cocoon.

frost line. An imaginary line below the surface of the soil. Above this line the water in the soil will freeze during the coldest winter days.

hibernator (hī'bẽr nā tẽr). An animal which spends all winter in a resting or sleeping state.

insect. A small animal with six legs and three body parts. Most insects have wings.

migrate (mī'grāt). To move regularly from one place to another, especially for food or for breeding.

nectar (nĕk'tẽr). A sweet liquid produced in the flower of a plant.

partial hibernator. An animal which spends only a part of the winter sleeping.

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FILMS

Farm Animals
Poultry on the Farm
Butterflies
Water Birds
Frog
Common Animals of the Woods

VI. WHAT MAKES CLIMATES?

MEANINGS FOR CHILDREN

Climates vary from place to place all over the earth. They even vary from place to place on one continent. Distance from the equator affects the climate of a place. There are five great temperature zones on the earth. Most places in the temperate zones have a warm summer and a cool or cold winter, although the average yearly temperature varies from place to place. Height above sea level affects the climate of a place. Nearness to a body of water affects the climate. Mountains in the way of the prevailing winds affect the climate.

YOU MAY NEED TO KNOW

We are apt to give the reason for the climate of any place in terms of its distance from the equator. This is natural because there are five great temperature zones on the earth and, in general, places with the warmest climates are located in the tropical zone. However, when we stop to consider average yearly temperatures of certain places on the earth, we are immediately aware that climates are influenced by factors other than distance from the equator. For instance, Quito, Ecuador, has an average yearly temperature of 57.2°F. Quito is on the equator. Monterrey, Mexico, is some distance from the equator. Yet Monterrey has an average yearly temperature of 71.2°F.

Quito, even though it is on the equator, is high in the mountains, whereas Monterrey is practically at sea level. Climates are affected by height above sea level. There is more air around our bodies at sea level, and the heat reflected from the earth is held close to the earth. In Chapter II, page 35, the reasons for cooler temperatures on mountaintops were discussed. You might wish to review these reasons with your children.

Water tends to make a climate more equable. That is, the winters are not so cold and the summers are not so hot as they might otherwise be. This is because the temperature of the water is raised slowly during the daylight hours. The temperature of

the soil is raised more quickly. When the sun is not shining, the soil gives up its heat quickly, whereas the water gives up its heat slowly. Consequently, during the winter season, when the hours of sunlight are few, a place near a large body of water is warmer than it would be otherwise. The water continues to give up stored heat during the winter months. In the summer, since water warms more slowly than soil, there is frequently a movement of air from the region over the water to the region over the soil. This makes for a cooler summer. In addition the air above the water continues to be cool since the water is absorbing heat more slowly than the land. Of course a place near the water has a more humid climate. There is always more water in the air. This often makes us feel warmer than we feel in a dry climate, but the temperature is not so great. We feel warmer in a more humid climate because water does not evaporate from our skin quickly, as it does in a dry climate. When water evaporates from our skin quickly, we feel cooler.

Ocean currents also affect the climate of a place. The Gulf Stream makes the south Atlantic coast of North America warm. The Labrador Current makes the New England coast and the Canadian Atlantic coast cool. The winds blowing from west to east across the Gulf Stream toward Great Britain and Europe make those regions far warmer than places which are located in North America at the same distance from the equator and the same height above sea level. When mountains cut off partially or almost wholly the prevailing, moisture-laden winds, a climate will be more dry. The Rocky Mountains partially cut off the warm, moisture-laden Pacific winds from the Great Plains of the United States and Canada.

WAYS OF PROCEEDING

If it is fall and children have just returned from summer vacations, or if it is spring and children are planning summer vacations, you will probably have a chance to discuss different climates. Or you may introduce this chapter at any time of the year by asking children to study the picture on pages 96–97 and to try to give the reasons for the various January climates shown there.

Introduction and Procedure. This chapter is not dependent upon other chapters in the book and may be used at any time of the year. You may find the material presented here useful in connection with certain social-studies materials. Suggestions for the introduction of this chapter are given above. The imaginary trips described and illustrated on pages 97–103 will give you more help in introducing this material. Perhaps your children will be able to tell a story about trips they have taken from one climate to another. Or perhaps they can describe other imaginary trips. Draw the attention of the children to pictures that illustrate differences of climate, like those on pages 104–105.

Use the earth globe and maps very freely when studying this chapter. If it is possible, a globe or maps showing physiographic features should be used. The various factors influencing climates are discussed in different sections of the chapter. Read and discuss and read again. Children will find it difficult to understand the reasons for climates if they try to read the entire chapter without adequate discussion as they proceed.

Something for You (p. 115). 1. The Canadian Rockies partially cut off moisture-laden winds from the Pacific.

2. Southern Argentina is more dry because the Andes Mountains cut off moisture-laden Pacific winds to some extent.

3. You could be cool in mountain regions in the tropics; for example, in the mountains of Central America.

4. Italy is a peninsula; the greater amount of water around it helps to give it a more equable climate. The Alps help to cut off cold fronts from the north.

5. Consider as many factors as possible; for example, altitude, nearness to a large body of water, and distance from the equator.

Further Activities. Make a physiographic map of your section of the country. Use a board for the map. You can make a mixture to use in modeling land features. Cut or tear newspaper into fine pieces and soak it in water overnight. Take 4 cups of this pulp. Squeeze the water out and add 2 cups of flour and 2 cups of salt. Mix thoroughly and apply. This may be molded, and when it has dried it may be painted to show land and water areas.

Evaluation. Using a physiographic map or globe, ask children to give reasons for the climates of such places as Chicago, Miami, Kansas City, and others. You will need to describe the climate under consideration before asking for the reasons.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

climate. The average condition of the weather at any place.
desert. Any part of the earth where there is very little plant life. There is not enough water in a desert for plants to grow well.
equator. An imaginary circle on the surface of the earth, which is exactly halfway between the north and south poles.
Guayaquil (gwī ä kēl′).[1] A city in Ecuador.
inland. The part of a country which is in from the coast.
ocean current. A vast stream within an ocean, flowing in a regular course.
polar. Of or having to do with one of the poles of the earth.
Quito (kē′tō).[1] A city in Ecuador about 9350 feet above sea level.
temperate. Neither hot nor cold; mild.
tropical. Very warm; hot; being within the tropics.
zone. One of the five great divisions of the earth's surface. The five divisions are the torrid zone, two temperate zones, and two frigid zones.

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SONDERGAARD, ARENSA. *My First Geography of the Americas*. Little, 1942.

FILM

Our Earth

[1]While the names of cities are geographical rather than science words, such as are difficult to pronounce are here given as aids to pronunciation.

VII. CLIMATES AND LIVING THINGS

MEANINGS FOR CHILDREN

Plants and animals are found all over the earth, even in hot and cold desert climates. But plants and animals which can live in warm climates cannot usually live successfully in cold climates, and vice versa. Plants and animals are adapted to the climate in which they live. Man is able to live in many different climates because he is able to adapt himself to varying climatic conditions.

YOU MAY NEED TO KNOW

Plants and animals have become adapted to the climates in which they live. In order to understand some of these adaptations, it would be well to understand first the climate of that particular place.

Many plants which grow in warm, dry regions either have small, tough leaves or long or spreading root systems. The small, tough leaves keep the plant from losing too much water. There is very little leaf surface from which water can evaporate. Long roots grow downward toward the water which is beneath the soil. Spreading roots take in much moisture after infrequent rains. Some annuals grow in hot desert regions. At the end of the moist season, these plants bear seeds. The seeds lie in the ground until there is enough moisture for growth. Then the seeds germinate and grow very rapidly. There is also animal life on hot, dry deserts. These animals live near water holes. Many of the animals are carnivorous, since it is difficult for them to find adequate plant food. The soil of hot deserts is often suitable for plant growth if there is enough water. The Imperial Valley is an irrigated desert region. The Nile Valley would be a desert if it were not watered by the Nile.

A desert is a place where there is not enough liquid water for proper growth of plants. There is plenty of water on cold deserts, but most of the year it is not in liquid form. Plants cannot take in frozen water through their roots. The water in the soil is also frozen to a depth greater than the roots of most plants. Again,

many animals living in this type of desert are carnivorous. Plant food is difficult to find. However, reindeer do exist by feeding on plants which they find under the snow. When the snow melts in the subarctic regions, seeds of the annuals germinate, grow, blossom, produce seeds, and die in a very short time. Liquid water is not available for plant growth for very long. People do live in cold desert climates, but most people would not find such living very pleasant.

Warm, moist climates are found near the equator. There is lush growth in such places because there is always sunlight, warmth, and moisture. Animal life abounds there, too. The seasons of such places might be described as the rainy and less rainy seasons. People live in these climates, but most people find warm, moist climates unhealthful and uncomfortable.

Many different kinds of plants and animals live and grow in the temperate regions of the earth. There is enough sunlight, warmth, and moisture for reasonable growth. A great many people live in the temperate regions. They find them healthful and comfortable regions in which to live.

WAYS OF PROCEEDING

This chapter may be used independently. However, it could very nicely either precede or follow Chapter VI, "What Makes Climates?"

Introduction and Procedure. Children, because of the great amount of air travel and talk about air travel, are becoming more and more conscious of climates other than their own. It is not unreasonable to suppose that a good many of the children you are teaching may visit many climates during their lifetime. This material may well be used in connection with social-studies materials which you may be teaching concerning people and customs of other lands. An understanding of world communities will be necessary for future citizens.

This is a chapter for individual or group reading and group discussion. Do not attempt to study the entire chapter at once; study it section by section. Enrich your reading and discussion

experiences with materials from magazines and books. Use pictures freely, and motion pictures and slides if it is possible. Make the most of the illustrations in the text and discuss them with the class. Have some of the persons in your community who have visited other climates come and talk with your children. You can make this a vital period of study.

Something for You (p. 151). 1. See *In Little America with Byrd*, by Joe Hill, Jr., and Ola D. Hill (Ginn and Company, Boston) and *Ambassadors in White*, by Charles M. Wilson (Henry Holt and Company, New York). You may find other stories too.

2. Dry soil becomes hot very quickly. Soil with vegetation warms less quickly because evaporation is slowed by plant life.

3. In the temperate zones.

4. Quick climatic changes would cause many plants and animals to become extinct.

Further Activities. 1. Choose a particular climate and study it rather intensively. Build a model village including the proper types of plants and animals. Or let several groups choose different climates for study.

2. Make a set of slides or make a "movie" on paper (a long mural rolled on a broomstick) to show the life and customs of the people and the types of plants and animals in different climates.

3. Have a play, the different scenes of which will show contrast of climates.

4. Get a cardboard carton or an orange crate. Cut away the top and front. Build a scene such as a snow scene or jungle scene or farm scene. Paint the inside of the back and sides of the box as a background. Use soil, grass, stones, twigs, and the like for the setting. Model and paint animals of clay. These scenes are called habitat groups. It would be interesting to have several committees, each one of which would be responsible for building a habitat.

Evaluation. 1. Individual work in the activities suggested above will give you some insight as to the ability of children to do re-

search and to organize materials. Help children to value accurate research. Help them to organize their materials.

2. Ask children to write the story of an imaginary visit to certain climates. Much subject-matter learning will be revealed by this experience.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

absorb. To take up or suck up as a blotter takes up ink.

antarctic (ănt ärk'tĭk). Having to do with the south pole or the region near it.

cactus (kak'tŭs). A prickly plant growing naturally in a warm climate.

Gila (hē'lȧ) **monster.** A poisonous lizard of the southwestern states.

jungle. Wild country overgrown with a thick, tangled mass of bushes, vines, trees, and other plants.

oasis (ō ā'sĭs). A place in a hot desert where there is enough water for trees and plants to grow.

penguin (pĕn'gwĭn). An aquatic bird incapable of flight whose habitat is the antarctic and south temperate regions.

poinsettia (poin sĕt'ĭ ȧ). A plant having brightly colored bracts, or leaves, below its less conspicuous flowers.

rain forest. A tropical forest where the plants grow very thickly because of the great amount of rain.

temperate zone. There are two temperate zones. They are the great divisions of the earth's surface between the tropic and the polar circles.

topsoil. The soil on the surface of the earth.

tsetse (tsĕt'sē) **fly.** A disease-carrying fly of Africa.

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LUCAS, JANNETTE M. *First the Flower, Then the Fruit*. Lippincott, 1943.

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FILMS

Navajo Children Eskimo Children People of Hawaii

VIII. SHAPES OF THINGS

MEANINGS FOR CHILDREN

The shapes of buildings, automobiles, trains, airplanes, and the like are not designed solely for beauty; the shape is also useful. Buildings and bridges must be well balanced so that they will stand. Boats, trains, airplanes, and automobiles have been streamlined. This not only makes them more beautiful, but it increases their speed. Some of the buildings of the world have been standing for a great many years. At the time they were built, men may not have understood the principles of balance, but they made use of these principles.

YOU MAY NEED TO KNOW

The engineers who design our modern automobiles and trains are concerned about their speed and efficiency as well as their beauty. The outside of an automobile or a locomotive is much smoother than it was only a few years ago. We say that the body is streamlined. The present smooth shape is more beautiful, and it is also more economical. A smooth, streamlined object can cut through the air to a greater distance than a nonstreamlined body, even though both bodies are moved by the same amount of force. This means that it will take less fuel to send a streamlined body through the same distance than a nonstreamlined body. The streamlined body is more efficient. Streamlined bodies travel faster too. The maximum speed of trains and automobiles has been increased partly because of better fuel, but the streamlined shapes also make the possible speeds greater.

Airplanes and boats also have streamlined shapes. The shape of an airplane is very like that of a bird. A bird's body is naturally streamlined. The feathers are smooth and sleek. The feet may be drawn up out of the way. The body is so shaped that a maximum amount of movement may be obtained for the expenditure of a minimum amount of energy. Fish too have naturally streamlined bodies. The shape of a submarine is much like that of a fish. Our modern ocean liners also have streamlined shapes. Air-

planes and boats are built so that they cut through the air and water with as much ease as possible.

All of us have had experience with balance. Very young children learn to make use of the principles of balance in their block-building. We often say that a vessel or a building or some other object must not be top-heavy if it is to stand properly. In other words, the base of a thing needs to be broader than the top, and the weight needs to be equally balanced around the center of the object if it is to be steady.

If you have ever watched children seesaw, or if you have played on a seesaw yourself, you have observed the principle of balance. If two people are about the same weight, they will balance if they are sitting about the same distance from the center of the seesaw. If, however, one person is heavier than the other, that person must sit nearer the center of the seesaw.

Bridges and buildings are so built that they are well balanced. Engineers and architects who design these structures are concerned about having weight equally distributed about the center of the object. Buildings are built with broader bases than tops so that they will not be top-heavy. The Pyramids have broad bases and narrow tops. This is true of many of our buildings.

Not only do we design well-balanced buildings, but we also design well-balanced furniture, glassware, lamps, and so on.

WAYS OF PROCEEDING

This chapter is entirely independent of any other chapter in the book. It involves experimenting, observing, discussing, and reading. You will have a chance to make full use of all these ways of learning in working with the materials of this chapter.

Introduction and Procedure. Ten-year-olds and eleven-year-olds almost invariably build model airplanes. They like to make and experiment with paper darts. When you see this interest springing up in your group, capitalize it. Talk about the shapes of the airplanes of today. Compare these shapes with pictures of the airplanes of ten and fifteen years ago. Ask your children why the shapes are smoother. If you wish to introduce this material

without waiting for a natural lead from your children, use the pictures on pages 152–153 as an introduction. The "Queer City" should arouse some discussion of the shapes of things. Take note of the square-shaped automobiles and airplanes. Ask why our airplanes and automobiles do not have these shapes. The buildings of the Queer City would have to be constructed very, very carefully if they were to stand. It is far easier to build a structure with a broad base than one with a narrow base.

Study the pictures of automobiles and trains on pages 154–157. Read about and discuss the differences between modern vehicles and older ones. Study the shapes of automobiles parked outside your school. Go to a railroad station to study a streamliner.

Try the experiment with the papers described on pages 158–159. Discuss the part air plays in this experiment. Let your children make and experiment with the paper gliders described on pages 160–161. Have the children discuss the pictures on pages 162–163 and give their views on the best strokes to secure speed in swimming. Then use the material on the shapes of airplanes and boats.

Borrow some blocks and have your children try to build the structures described and shown on pages 168 and 169. Let them try to design and build other top-heavy structures. If your playground has a seesaw, experiment with it to get the feeling of balance. Now read and discuss the materials on pages 172–182. Collect pictures of other buildings. Study them for balance. Take a walk and study the buildings you pass.

Something for You (p. 183). 1. The bases are broad. If the legs were placed near the center of the bottom, they would tip over when you used them.

2. The base is not broad enough.

3. Lamp bases are usually broad and flat and often heavy.

4. Yes, usually.

5. Trying to draw a building will help children to notice its design and construction.

6. Probably. Children might be interested in seeing plans for some building as drawn by the architect.

Further Activities. 1. Make a bulletin board of pictures showing objects which are well balanced and objects which are not well balanced.

2. Watch younger brothers or sisters playing with blocks. What are they beginning to learn about balance?

3. Let children design new automobiles or airplanes or trains or buildings. Discuss the streamlined appearance.

Evaluation. Try a picture test. Draw on the board a Queer City of your own design. Let children find as many things as they can which are unbalanced or nonstreamlined. You will have a chance to watch for evidence of progress in initiative.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

arch. A part of a structure that is curved or that is rounded to a peak.
balance. The state of equality between weights or masses.
design (dē zīn′). The arrangement of the details of a piece of work; a plan of something to be made.
glider. An object that moves smoothly and silently; an aircraft similar to an airplane but with no engine.
pyramid (pĭr′*ȧ* mĭd). A large structure, usually with a square base, the walls of which meet in a point. The Pyramids of Egypt were used as tombs.
roadbed. In railroads the foundation on which the ties and rails rest; the material of which highways are made, laid in place and ready for travel.
soar. To fly upward, as a bird.
streamline. To make the outside of a body as smooth as possible.
suspension. The state of being suspended, or hung.

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FILMS

Passenger Train   Airplane Trip   Boats   Shelter   Bus Trip

IX. FAIR DAYS AND CLOUDY DAYS

MEANINGS FOR CHILDREN

Climates change, but only over long periods of time. Weather changes from day to day. The atmosphere is a part of the earth. It extends outward from the land and water areas of the earth. The air expands when it is heated, and contracts when it is cooled. Air circulates. Cooled, heavier air is pulled downward by gravity. This cooled air pushes up the warmed, lighter air. Air may circulate in small areas, such as a room. It also circulates over larger land areas. The movement of air from one place to another may be called a breeze, a gentle wind, a strong wind, or a gale according to the speed of the movement of the air. There is water in the air. This moisture is in the form of invisible water vapor. It condenses into forms we know as clouds, rain, snow, hail, dew, and frost. Thunderstorms are accompanied by lightning and thunder. Tornadoes and hurricanes are very rapid air movements.

YOU MAY NEED TO KNOW

Weather is the sum total of changes in the atmosphere. Weather affects our daily lives greatly. A climate may change, but only over long periods of time. Weather changes from day to day or from hour to hour. For instance, a temperate climate remains temperate for a long period of time. But a temperate climate may have cold, hot, rainy, and dry weather during a single year.

The air is a very real thing, although we cannot see it. When the air is heated, it expands, or spreads out. When it is cooled, it contracts. Because of this heating and cooling, air moves from one place to another. It circulates. Cooled air is heavier than warmed air because there is more air in a given space. Cooled air is contracted air. This heavier, cooled air is pulled downward by gravity. When this happens, the warmer, relatively lighter air is pushed upward. This effect may be noticed over a fire, over a radiator, or over a hot roadway. The dust particles in the air move upward in the warmer air. A breeze or a wind is caused by unequal heating of the earth's surface. Cooler, heavier air pushes

warmer, lighter air upward and outward, thus causing a circulation of the air.

Water evaporates and becomes a part of the air in the form of invisible water vapor. When the air is cooled sufficiently, this vapor may condense to form clouds of visible water droplets. The white cloud over a pan or kettle of hot water is condensed water vapor. It is not steam. Steam is hot, invisible water vapor. Rain and dew are forms of condensed water vapor. They are droplets of liquid water. Frost forms when water vapor condenses on an object which is below 32° F. Snow forms where the air temperature is below 32° F. Sometimes as water condenses out of the air, it forms ice crystals which we call snow. Sleet is frozen rain or frozen, partly melted snowflakes. Hailstones are frozen water. They begin as droplets of water falling from a cloud. Falling into a layer of cold air, the droplets freeze. Then passing through warmer air, they gather moisture. Being lifted by rising warm air, they again strike a colder air and the added moisture freezes. This process may be repeated several times. Finally the hailstones become so heavy that they drop to the earth.

A good part of the United States and Canada lies in the region of prevailing westerly winds of the north temperate zone. Global wind movements in this area are from west to east. These winds cause areas of lighter, warmer air, known as low-pressure areas, to move across the continent from the Pacific to the Atlantic. These same prevailing westerlies cause heavier, cooler air, known as high-pressure areas, to move in the same direction. The heavier and cooler air from the surrounding country flows from all directions toward the low-pressure area. When this air reaches the low-pressure area, it moves upward. The water vapor in the air is cooled as the air moves upward and is cooled. Clouds are thus formed, and rain or snow or sleet or hail may fall.

Low-pressure areas are called cyclones. High-pressure areas are called anticyclones. Cyclones and anticyclones never remain in one place in the region of prevailing westerlies. They move with the global wind current from west to east.

Storms are associated with low-pressure areas. This is because the air containing water vapor is moving upward into cooler

regions. Therefore the water vapor may condense. The rapid upward movement of air in a thunderhead may cause charges of electricity to be built up. When the electricity is discharged, we see lightning. Thunder occurs almost simultaneously with the lightning but is not heard until later, because sound travels only about 1100 feet per second whereas light travels about 186,000 miles per second. Tornadoes and hurricanes are areas of extremely low air pressure.

WAYS OF PROCEEDING

This chapter should probably precede or be used in conjunction with Chapter X, "Watching the Weather."

Introduction and Procedure. The chapter may be introduced by calling the attention of children to weather changes. Have a lively discussion. Keep a record for two or three days to show weather changes. Or you may wish to introduce this material just after your children have experienced some unusual weather, such as a thunderstorm or a heavy snowstorm.

This chapter lends itself to observation, discussion, and research. The experiments on pages 187–189 should arouse interest in the "whys" of the weather. In connection with circulation of air, observe how dust moves upward with heated air.

Be sure to do the experiment on page 195. It will be much easier for children to understand rain and snow formation after they have done this experiment. The same is true for the dew experiment on page 197. Pages 198–206 are concerned with observation, reading, and discussion. Stop to question and discuss frequently.

Discuss with the class the picture on page 201, showing how hailstones are formed and why they may grow bigger until they finally fall to earth.

Materials Needed. Pyrex bottle, balloon, birthday candle, pan, quart milk bottle, electric plate or Sterno set, teakettle, plate, jar, ice.

Something for You (p. 207). 1. Warm air being pushed upward turns the pinwheel.

2. It is moving upward with the warmed air.

3. Yes, apparently animals feel weather changes, too. A dog's tongue hangs out on a hot day. A bird fluffs out its feathers on a cold day.

Further Activities. Call attention to weather reports in the newspaper and over the radio. Call attention to weather maps. This is in preparation for Chapter X, "Watching the Weather."

Evaluation. Allow much time for discussion. Keep some type of check on individual contributions. Everyone should be able to contribute to this study. Here is a test which will help both you and the children to check their subject-matter learnings. The statements are marked correctly. The statements may be put on the blackboard or prepared on the hectograph.

(*T*) 1. Air contracts when it is cooled.
(*T*) 2. Warmer, lighter air is pushed upward by cooler, heavier air.
(*F*) 3. Snow is frozen rain.
(*T*) 4. Sometimes air presses more on us than it does at other times.
(*T*) 5. A wind is a movement of cooler air toward warmer air.
(*F*) 6. When water comes out of the air, we say water evaporates.
(*F*) 7. Steam is the white cloud above a kettle of boiling water.
(*T*) 8. Storms move across most of the United States and Canada from west to east.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

condensed (kŏn dĕnst′). Made more compact or dense.

crystal (krĭs′tăl). Body formed by a substance solidifying so that it has flat surfaces arranged symmetrically.

current. A flowing or moving onward, somewhat like a stream.

damper. A valve or plate in the flue of a stove or fireplace used to regulate the draft.

dew (dū). Moisture condensed upon the surfaces of cool objects.

draft. A current of air; a device for regulating the supply of air in a stove, furnace, fireplace, and the like.

evaporate (ē văp′ō rāt). To pass off as vapor.

gale. A very strong wind which has a speed of between 35 and 75 miles an hour.

hail. Small roundish lumps of ice that fall sometimes during thunderstorms.
hurricane. A bad storm, beginning over the ocean, with winds up to 100 miles an hour.
lightning. The light which is caused by a flash of electricity in the atmosphere.
moisture. Very small amounts of water.
pressure. A push.
sleet. Partly frozen rain that usually forms a coating on objects as it falls.
snow. Small flakes of frozen water formed from the water vapor of the air when the temperature is below freezing.
thunder. The loud crashing or rolling noise that follows a flash of lightning.
thunderhead. A large, dark rounded cloud often appearing before a thunderstorm.
tornado. A very strong whirling wind with a funnel-shaped cloud. A tornado is very destructive.
vapor. A gas. Steam is water vapor. Anything turns to vapor if it is hot enough.
weather. The condition of the atmosphere with respect to heat, cold, dryness, wetness, clearness, cloudiness, and so on.
weather report. Information about the condition of the weather supplied by a weather bureau.

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FILM

The Weather*

*Films so designated are somewhat advanced in comparison with the text, but may be useful for some groups.

X. WATCHING THE WEATHER

MEANINGS FOR CHILDREN

Forecasting the weather depends on a knowledge of air temperature, air pressure, air speed, and air direction. Air temperature is measured with a thermometer. The temperature of the outside air must be taken for weather forecasting. Air pressure may be measured with an aneroid barometer. Air pressure may be taken either inside or outside. Lower air pressure indicates cloudier, stormier weather. Higher air pressure indicates fairer weather. Air speed is measured in terms of miles per hour. Workers at weather stations scattered throughout North America report weather conditions to Washington, D. C., and Toronto, Canada. Weather reports are recorded on weather maps. Forecasts are made from data on weather maps. Weather reports are very useful to us.

YOU MAY NEED TO KNOW

A weather forecaster is a trained weather observer. Forecasters note the temperature, air pressure, and speed and direction of the wind. They also measure air humidity and the amount of precipitation.

The temperature of the air is measured out of doors with a thermometer. The thermometer should be shaded from the sun. Directions are given on page 211 for setting up an outdoor thermometer station. The picture on page 219 shows a thermometer house. The thermometer is inside the slatted house. The slatted sides allow free circulation of air, but the thermometer is shaded from the sun.

Air pressure may be measured with an aneroid barometer. Inside the barometer case is a partially evacuated, small metal box. When air pressure increases, the sides of this box are compressed, and the dial needle moves to the right. This is in the direction indicating fairer weather. When air pressure decreases, the box expands slightly, and the dial needle moves to the left. This is in the direction indicating stormier weather. Warm,

moist air is lighter than cooler, drier air because there is less air in a given volume of the warm air.

The speed of the wind is measured at weather stations by an anemometer. The anemometer in the picture on page 219 is the instrument with the four cups. As the wind whirls this instrument, a gauge shows the air speed. Wind direction is indicated by a wind vane or wind sock.

Weather reports are sent from stations in the United States to Washington, D. C. In Canada the reports are sent to Toronto. These two centers exchange reports. Data are recorded on maps. These data include thermometer readings, barometer readings, anemometer readings, and the like. Since the high-pressure and low-pressure areas in this region move in a generally west-east direction, study of these data helps in forecasting. The same general weather that is reported west of a place may be expected to arrive within a certain number of hours, according to the speed at which the pressure area is moving.

Weather reports are given out in newspapers or over the radio. These reports are of great value to such workers as fishermen, farmers, gardeners, and bakers. A visit to your local weather station will prove to be very interesting to you.

WAYS OF PROCEEDING

This chapter should follow or be used in conjunction with Chapter IX, "Fair Days and Cloudy Days."

Introduction and Procedure. If children have worked on the materials presented in the preceding chapter, they will probably want to try to forecast the weather. If they have not studied weather, you may wish to arouse their curiosity by asking how the weather is forecast and why forecasts are not always accurate.

Keep a record of weather changes for two or three days and ask the children to tell which things about the weather have changed. They will probably note the changes in air temperature, speed, and direction. Ask them to keep accurate records of these.

The chart on page 212 is a record of air temperature for two weeks. Read the air temperature in a shaded place. The ther-

mometer could be fastened outside the window. Or your group might build a station like the one pictured and described on page 211.

Air pressure may be read from an aneroid barometer. If you cannot get such a barometer, look in the newspaper weather report for barometer readings. Barometer readings are often given in morning radio weather reports. Keep a record of air-pressure changes.

Air speed may be estimated by using the chart on page 217. Keep a record of air speed and air direction.

If you live in the region of prevailing westerlies, you will find that during the winter the low-pressure areas usually last about three days. These are usually followed by high-pressure areas which last also about three days.

Try to take your group to visit a weather station. The workers at the station will explain many interesting things.

Collect a series of weather maps from the newspapers. Check the records with your own experimental records. Note how the highs and lows move from west to east.

Have your children think of as many ways as they can that people make use of weather reports.

Materials Needed. Thermometer, aneroid barometer.

Something for You (p. 227). 1. More complete information helps to make weather forecasts more exact.

3. When the air pressure is greater, water is forced down in the spout; when air pressure is less, water rises in the spout. If the air pressure is quite low, water sometimes drips out of the spout. This type of barometer is not very accurate because the water also expands and contracts with changes in the temperature of the air.

Evaluation. This chapter gives a chance for much individual work. Check as to whether children can read a thermometer accurately and record the reading. Do the same for air pressure, speed, and direction. Draw a sample weather map. Give necessary data and ask children to try to predict the weather.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

air pressure. Air does not seem to weigh anything. Yet air does weigh something, and so it presses on us. This is air pressure.

anemometer (ăn ē mŏm'ē tẽr). An instrument which measures the speed of the wind.

aneroid barometer (ăn'ẽr oid bȧ rŏm'ē tẽr). An instrument which measures air pressure. This kind of barometer uses no liquid.

barometer (bȧ rŏm'ē tẽr). An instrument which measures air pressure.

forecast. To tell about a happening before it takes place. A person who tells what the weather will be is said to forecast the weather.

high-pressure area. A place where the air pressure is highest.

instrument. A tool.

low-pressure area. A place where the air pressure is lowest.

predict. To tell beforehand.

Weather Bureau. A bureau of the Department of Agriculture which collects reports of weather conditions. One of the duties of the Weather Bureau is to make forecasts.

wind scale. A table of words or numbers used to tell the force of the wind.

wind vane. A device which shows which way the wind blows.

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FILM

Orange Grower

XI. ABOUT MAGNETS

MEANINGS FOR CHILDREN

There are several kinds of man-made magnets. Some of them are the horseshoe magnet, the U magnet, and the bar magnet. Magnets may be made by stroking a piece of iron with a magnet or by leaving a piece of iron near a magnet for a while. Each of these magnets has one north and one south pole. Unlike magnetic poles attract each other; like magnetic poles repel each other. Magnetism goes through some things, but not through others. There is a magnetic field around every magnet. A compass uses a magnet. No one really knows why a magnet is a magnet, but many scientists think it is because the molecules are lined up. The earth is a large magnet; so is the sun. The earth has a north magnetic pole and a south magnetic pole as well as a north geographic pole and a south geographic pole.

YOU MAY NEED TO KNOW

No one knows when the first magnets were discovered. Pieces of magnetized iron, called loadstones, are found in the earth. These were the first magnets. They probably were of little use to man at first.

Later, men discovered that a floating magnet would point in a generally north-south direction. A magnetic compass uses this principle. A compass needle is a small bar magnet which is so placed that it is free to turn around.

Most magnets have only two poles. The north pole, or end, of the magnet will point north if the magnet is suspended. In like manner, the south pole points south. Now we know that north poles of magnets repel north poles and that south poles repel south poles. Unlike poles of magnets attract each other. That is, north poles attract south poles. You may wonder, then, why the north pole of a compass needle points to the earth's north magnetic pole. Actually, it does not. All our magnetic poles should properly be renamed. The pole of a magnet which is called a north pole is really a south pole; so the south pole of a magnet

really does point to the north magnetic pole of the earth. This confusion arose because men knew that magnets would point in a north-south direction and so named the poles before they realized that the earth had two magnetic poles. So we continue to say that the north pole of a magnet points north. Probably it would be better to call that end of a magnet the "north-seeking" end.

All substances are probably more or less magnetic. However, since iron and steel exhibit magnetic properties to a greater extent than other substances, we usually think of them as magnetic. Recently, very powerful magnets have been made of an alloy of aluminum, nickel, and cobalt. These are known as alnico magnets. These magnets retain their magnetic properties for a long time. Alnico magnets are more expensive, but they are worth buying if you want a fairly permanent piece of equipment.

We do not know why magnets are magnets. The theory of magnetism given on pages 233–236 is the best explanation available at the moment. Physicists are engaged in research on this question now. They seem to think that magnetism and electricity are very much alike. We may have new magnetic theories before long.

Magnetism usually passes through nonmagnetic materials, such as wood and paper, if the nonmagnetic material is not too thick. Magnetism usually will not pass through iron or steel. However, if a strong magnet is used with a thin piece of iron, some magnetism will pass through. The area around a magnet in which the magnet exerts its magnetic properties is known as a magnetic field. The size of this field varies with the strength of the magnet.

The earth is a magnet. Its magnetism is probably due to the fact that it is within the magnetic field of the sun. The maps on pages 246 and 247 give the location of the magnetic poles.

Your watch may become magnetized if you get it too near a strong magnet. It is best to remove it when using magnets.

WAYS OF PROCEEDING

This chapter is independent of all others and may be used at any time of the year.

Introduction and Procedure. Children often bring magnets or compasses to school. If they do, begin the work at this time. If they do not, all you will need to do is to place a magnet or a compass on a table so that children may use it during their free time. Interest will immediately be aroused.

The materials presented in this chapter lend themselves to much experimenting. Allow as much free experimentation as possible. Even though certain ideas are presented in group work, your children will enjoy working with magnets on their own. Do not merely read about magnets; work with magnets. The chapter may be followed through as it is presented, or the various sections may be used independently.

Materials Needed. Horseshoe magnet; bar magnet; compass; iron filings; large nail, steel knitting needle, or knife; tacks or small nails; piece of glass, copper, or zinc; piece of tin.

Something for You (p. 249). 1. Each piece would have one north and one south pole.

2. The north pole could be called a north-seeking pole and the south pole a south-seeking pole.

Further Activities. 1. Make a magnetic-fish game for younger children. Put paper clips on cardboard fish. The "hook" of the fishing line will be a magnet.

2. Make magnetic boats from flat pieces of cock. The sail should be paper and the mast a needle. Make the boats move by bringing a magnet near.

Evaluation. Watch individual progress, especially in regard to experimenting and theorizing. Use true-false statements like these for a subject-matter test:

(*F*) 1. Like magnetic poles attract each other.
(*T*) 2. The north magnetic pole of the earth is in Canada.
(*T*) 3. A piece of iron may become a magnet if it is left near a magnet for a long time.
(*T*) 4. It is thought that the molecules in a piece of iron line up when it becomes a magnet.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

attract. To draw to itself.
compass. A magnetic instrument which may be used to tell directions.
geographic pole. Either end of the axis of the earth. The north pole and the south pole are the geographic poles.
iron filings. Very small pieces of iron.
magnet (măg'nĕt). A piece of iron or steel that attracts to itself other pieces of iron or steel.
magnetic (măg nĕt'ĭk) **field.** The space around a magnet through which a magnet pulls iron or steel toward itself.
magnetic poles. The two spots on the earth's surface toward which a compass needle points. They are called the north magnetic pole and the south magnetic pole.
magnetism. The property by which certain substances attract other substances.
magnetize. To cause a piece of iron or steel to become a magnet.
microscope (mī'krō skōp). An instrument which makes a very small object look big.
molecule (mŏl'ĕ kūl). A very small, invisible particle of a substance.
particle. A very, very small part of anything.
rotate. To turn around on an axis, as a wheel turns on its axis or as the earth turns on its axis.
theory. The best guess we can make from known facts in order to explain something.

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XII. ABOUT ELECTRICITY

MEANINGS FOR CHILDREN

Magnets may be made by using electricity. These magnets are called electromagnets. Electromagnets usually remain magnetic only so long as the electricity is flowing. If the electricity remains on long enough, the soft-iron core will remain magnetic for a long time. Electromagnets may be made stronger by increasing the number of turns of wire around the soft-iron core or by increasing the electricity or by doing both these things. An electromagnet has a north pole and a south pole. The poles of an electromagnet may be reversed by reversing the electric current. Electromagnets have many uses. A complete circuit must be made before electricity will flow. Electricity is used for lighting. A dry cell furnishes electricity. A dry cell does not really make electricity; it changes chemical energy into electrical energy.

YOU MAY NEED TO KNOW

Electromagnets are made by winding insulated wire about a piece of soft iron, such as a nail. The two ends of the wire are then connected to a dry cell or some other source of electricity. Bar magnets or U magnets or horseshoe magnets may be made by leaving the electric current connected for a long time. The soft-iron core of an electromagnet often retains some magnetism for a while after the current is turned off. Electromagnets have a north pole and a south pole. As with other magnets, like poles repel and unlike poles attract. The polarity of an electromagnet may be determined by bringing a compass or a marked magnet near the electromagnet. The north pole of the compass needle will be attracted to the south pole of the electromagnet and vice versa. The poles of an electromagnet may be reversed by reversing the connections at the dry cell. An electromagnet may be made stronger if more turns of wire are wound on the soft-iron core. Or, it may be made stronger by putting another dry cell in the circuit. Or, both of these things may be done to make an electromagnet stronger. Electromagnets are used for lifting scrap

iron. They are also used in some radio sets and in telephone and telegraph instruments.

Dry cells may be used to make a flashlight bulb glow. Try the experiment on page 258. You will find that a complete circuit must be made before the electricity will flow. Be sure that all connections are tight.

Electricity from a dry cell will not harm you or the children. Dry cells are perfectly safe to work with. It is the amount of electrical pressure which will cause a shock. The ordinary house circuit has an electrical pressure, or voltage, of 110 volts. A dry cell has usually only 1.5 volts. Dry cells have two connecting posts, or terminals. The center terminal is called the positive post; the terminal connected to the zinc can is called the negative post. A flashlight dry cell has two posts, also. The positive terminal is at the center of one end; the entire zinc can acts as the negative terminal. When you open a dry cell with children, use a good one. Children often think that electricity may be seen and has escaped from a dead cell. In order to convince them that electricity cannot be seen, you may need to use a good dry cell, having first demonstrated that the cell can light a flashlight bulb. The black paste in the dry cell is usually a mixture of the following chemicals: ammonium chloride, manganese dioxide, zinc chloride, coke, and graphite.

Do not allow children to try to use the house electricity for experimenting. It is too dangerous.

WAYS OF PROCEEDING

This chapter may be used independently or in conjunction with Chapter XI, "About Magnets." Each of the sections may be used separately. You may want to work with the light bulb and open a dry cell before discussing electromagnets.

Introduction and Procedure. If you use Chapter X first, the work on electromagnets in this chapter will introduce the study of electricity quite naturally. If you do not study magnets first, you may wish to introduce this material by placing a dry cell, insulated wire, a switch, a flashlight bulb, and a socket on the table.

Ask the children to see if they can make the bulb light. A discussion of complete circuits will naturally follow. Then you may wish to talk about how the electricity flows through the circuit. Next you may wish to open a dry cell. Then you may want to experiment with electromagnets.

Do not forget that children like to work alone on this material. If class experimenting and committee demonstrating are done, be sure to allow plenty of time for individuals to repeat the experiments. Only in this way can you be sure that each child has an opportunity to understand fully.

You should point out to the children that an electromagnet like the one pictured on pages 250–251 usually picks up pieces of iron only when the current is on and drops the pieces when the current is turned off. If the electricity remains on for quite a while, the iron core may remain magnetic for some time.

Materials Needed. 10 feet of insulated copper bell wire, flashlight bulb and socket, two or three dry cells, switch, large nail, compass.

Something for You (p. 265). 1. A storage battery is usually made of three or more wet cells connected together. The chemicals between the poles of the cells in a storage battery are in liquid form.

2. The electromagnet is a U-shaped magnet in the receiver. As the electromagnet is made stronger and weaker by increased and decreased current, the diaphragm of the receiver is attracted and released. This movement of the diaphragm sets up air vibrations. These air vibrations affect our eardrums, and we hear. Sound does not travel over telephone wires. (See *Science for the Elementary-School Teacher*, pages 482–483, for a more complete explanation of the telephone.)

3. Directions will be found on pages 478–479 of *Science for the Elementary-School Teacher*.

4. Do this yourself. Be sure that the bulb is completely wrapped. Help children to compare the bulb with the drawing on page 260 of the text.

5. The electricity comes from a power plant.

Further Activities. 1. Try to find out if there is a large commercial electromagnet in use near you. Visit the place and watch the electromagnet.

2. Visit a power plant. Ask the engineer to explain how electricity is produced there.

3. Visit the telegraph office and watch the sending and receiving of messages.

Evaluation. 1. Since the materials of this chapter lend themselves so well to individual and small-group experimenting, do as much of this as possible. Encourage all the children to work with the materials. See to it that a few do not monopolize the science table. Watch for signs of individual progress in initiative and in co-operation.

2. Use a picture test to evaluate subject-matter learnings. Here are some sample problems:

a. Draw a light bulb. Show the path of electricity with a colored crayon.

b. Draw a cut-away dry cell. Label all the parts you know.

c. Draw a complete electromagnet circuit. Label the parts in your circuit.

d. Draw a cut-away electric socket. Show where electricity may enter and leave the socket.

e. Draw a picture showing an electromagnet circuit. Now draw another circuit showing a stronger electromagnet.

3. You may wish to have children make a large mural on brown wrapping paper, which will show the uses of electricity. This will help you to evaluate the work of individuals. Before beginning the mural, let each child make a list of as many uses of electricity as he can. Everyone should be able to make such a list. All the children will be able to contribute to the mural.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

chemical (kĕm'ĭ kăl) **mixture.** All things are made of chemicals. Iron, copper, carbon, water, and salt are chemicals. A chemical mixture is a mixture of chemicals.

electric (ē lĕk'trĭk) **circuit.** The path over which a stream of electricity travels.

electricity (ē lĕk trĭs′ĭ tĭ). A form of energy caused by the movements of very small particles of matter called electrons.

electromagnet (ē lĕk′trō măg′nĕt). A magnet made by winding an insulated wire around a piece of soft iron. When electricity goes through the wire, the iron becomes a magnet.

insulated (ĭn′sū lāt ĕd). Prepared in such a way that electricity will not pass out of the material. A copper wire wound with silk or cotton thread is an insulated wire. Electricity will pass through the copper wire but will not pass out through the thread.

key of a switch. The movable metal connecting bar of a certain type of electric switch. Pressing down the key of the switch completes the circuit.

socket. A hollow thing in which something else similarly shaped may be fitted.

storage battery. A group of cells containing chemical substances that create and store up electricity.

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FILMS

Home Electrical Appliances* Safety in the House

*Films so designated are somewhat advanced in comparison with the text, but may be useful for some groups.

XIII. KNOWING PLANTS

MEANINGS FOR CHILDREN

There are many, many kinds of living things, but they may be divided into two large groups, plants and animals. There are many different kinds of plants. Some have only one cell; others have many. The cells of all plants contain protoplasm. Green plants manufacture food; nongreen plants do not. Yeasts are one-celled plants. Yeasts, molds, and mushrooms do not make their own food. These plants do not have flowers or seeds. Some one-celled plants are called algae. These green plants make their own food. Ferns make their own food; they have no flowers or seeds but reproduce by means of spores. Flowering plants make their own food; they also produce seeds. Many flowering plants are useful to us. Some new flowering plants may grow from roots, stems, and slips of old plants as well as from seeds. All evergreens make their own food and seeds. However, some evergreens, such as firs, do not produce conspicuous flowers.

YOU MAY NEED TO KNOW

All living things are made up of one or more cells. These cells contain protoplasm. Protoplasm may differ in the various types of plants or animals.

Algae and bacteria are one-celled plants. They reproduce by cell division. Green algae make their own food. The green material, chlorophyll, is necessary for food-making. A green plant takes in carbon dioxide and water. These two materials are combined in the presence of light in the cells containing chlorophyll. The food which is made in this way is sugar. Oxygen is a waste product in this process and is given out into the air.

Yeasts are nongreen, one-celled plants. They reproduce by cell division. They use sugar for food. Molds reproduce by means of spores. Mushrooms and puffballs are nongreen plants. They also reproduce by means of spores.

Ferns are food-making plants. True ferns do not have blossoms. They produce spores.

Flowering plants, such as deciduous trees, garden flowers, and crop plants, produce seeds. These are all many-celled, food-making plants. We do not often notice the flowers of deciduous trees and crop plants. You will find it interesting to look for them. Flowering plants are grouped according to flower and leaf structure. Some flowering plants are also able to reproduce by means of stems, roots, and slips or cuttings.

WAYS OF PROCEEDING

This chapter is entirely independent of any other chapter. It would probably be interesting to work with these materials both in the fall and in the spring. By so doing, your children will have an opportunity to observe seeds and flowers as they are being produced.

Introduction and Procedure. This material might be introduced by bringing in a collection of different kinds of plants, such as a flowering plant, a mushroom, mold, yeast, and so on. Or you might introduce it by asking children, in a discussion group, to name as many plants as they can. You will be able to supply the names of some unusual plants.

Discuss the picture on page 271 with the children so that they will acquire some understanding of the important process of food production in plants.

As you work through the chapter, use as many specimens as you can. Encourage children to bring in plants for observation. Grow mold and examine it with a hand lens. Do the yeast experiment on pages 275–276. Take seeds apart and find the small plant surrounded by food materials. It is often best to soak a seed before opening it. Let individual children take apart a flower and find the sepals, petals, pistils, and stamens. Grow plants from seeds, cuttings, stems, and roots.

As you can see, this can be an interesting chapter, full of activity. Do not forget to take as many observation trips as possible into the out-of-doors.

Materials Needed. Cake of yeast, piece of bread, potato, plants, seeds, bulbs, pots, hand lens.

Something for You (p. 303). 1. Plants are alike in that they have one or more cells and all contain protoplasm. Plants are different in these ways: Some plants have one cell, and others have many; some are green and can make their own food; some have flowers; some have seeds. All flowering plants grow from seeds. Yeasts, algae, molds, mushrooms, and ferns are a few plants which do not grow from seeds.

2. Yes, they do.

3. Do as much of this as possible. With some guidance children can become keen observers.

Further Activities. 1. Visit a greenhouse.

2. Look at one-celled plants through a microscope.

3. Make a bulletin board or a mural showing plant groups.

Evaluation. This material lends itself to individual research and reporting according to individual capacity. Let your slower children feel the satisfaction of reporting to the group. Your faster children will be able to do much individual research. Help all your children to value accurate research and reporting.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

algae (ăl'jē). A group of green plants. Some of these plants live in salt water, some in fresh water, and some on land.

anther (ăn'thẽr). The part of a stamen in a flower which makes pollen.

bacillus (bȧ sĭl'ŭs). Any rod-shaped bacterium.

Boletus (bŏ lē'tŭs). A kind of mushroom.

carbon dioxide (kär'bŏn dī ŏx'īd). One of the gases found in the air. It is used by green plants to make food.

cell (sĕl). Every living thing is made up of one or more cells.

cepe (sēp). An edible species of Boletus mushroom.

chlorophyll (klō'rō fĭl). The green coloring matter in plants which is used in food-making.

colony. A number of plants or animals of the same kind living together.

cutting. A section cut from a plant, such as a stem cutting.

domesticated. Tamed. Horses, cows, dogs, and cats are domesticated animals.

egg cell. The cell in a plant which may, when fertilized, develop into a seed.

fertilization (fûr tĭ lĭ zā'shŭn). The union of a female and a male germ cell to form a new plant or animal.

mildew (mĭl'dū). A kind of mold.

mold. A small plant which grows on decaying plant or animal material.

mushroom. A fungus with an umbrella-shaped cap.

petal (pĕt′'l). The white or colored leaves at the base of a flower.

pistil (pĭs′tĭl). The part of a plant in which the egg cells grow. Pollen falls on the top of the pistil and grows down through it to reach the egg cells.

pollen (pŏl′ĕn). The yellow dust produced by seed-producing plants. Pollen contains sperm cells, which fertilize egg cells.

prothallium (prō thăl′ĭ ŭm). A stage in the development of a fern from a spore.

Protococcus (prō tō kŏk′ŭs). A kind of one-celled green alga.

protoplasm (prō′tō plăz'm). A colorless material of which all living things are made.

runner. A slender branch which grows out over the surface of the ground from the parent plant.

sepal (sē′păl). One of the small green leaves which protect a flower bud and which remain just under the petals when the flower opens.

sperm cell. The cell which fertilizes an egg cell.

Sphaerella (sfē rĕl′ȧ). A one-celled plant.

Spirogyra (spī rō jī′rȧ). A kind of common green alga.

spore. A single cell or group of cells, formed on some kinds of plants such as ferns, from which new plants of the same kind will grow.

stamen (stā′mĕn). The part of a seed-making plant which produces pollen.

weed. Any plant which is not wanted in a garden or field.

yeast (yēst). A one-celled plant which cannot make its own food.

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FILMS

Plant Growth
Roots of Plants
Leaves
Fungus Plants
Gardening
Flowers at Work
Seed Dispersal

XIV. KNOWING ANIMALS

MEANINGS FOR CHILDREN

There are many, many kinds of living things, but they may all be divided into two large groups, plants and animals. There are many different kinds of animals. Some have only one cell; others have many. The cells of all animals contain protoplasm. No animal is able to manufacture food. They all depend on green plants or on other animals for food. Many animals do not have bones; others have simple or well-developed skeletons. Some animals reproduce by cell division. Other animals lay eggs, and some animals bear their young alive. Some animals live in the soil; some live in the water; others live above the soil or water. Some animals, such as insects, frogs, and toads, go through several changes as they mature. Some animals have lungs; others do not. Animals have different coverings. Some animals are cold-blooded; others are warm-blooded. Some animals do not take care of their young; others take care of their young for a long time.

YOU MAY NEED TO KNOW

No animal is capable of manufacturing its own food. Some animals are one-celled; others have many cells. Some have no skeletons; others have simple or well-developed skeletons. Some animals are cold-blooded; others are warm-blooded. A cold-blooded animal's body temperature varies with the air or water around it. A warm-blooded animal's temperature is constant. Birds and mammals are warm-blooded.

One-celled animals reproduce by cell division. They need warmth, moisture, and food for proper growth. Air, water, and food pass through the cell wall into the inner part of the cell. Earthworms do not have skeletons. They must live in moist soil. They are very useful because they aërate the soil. Earthworms move by means of small projections on the underside of the body called setae. An earthworm produces a cocoon containing eggs. A single earthworm produces both egg and sperm cells, although earthworms usually exchange sperm cells. Fish are cold-blooded.

They usually have scales. They have a skeleton. They have gills all their lives. Most fish lay eggs which are fertilized by the male after they have been laid. The male deposits sperm cells, or milt, over the eggs. The eggs of some female fish are fertilized within the body. In this case, the young are born alive. Snakes are cold-blooded and have skeletons. They are reptiles. Few snakes are poisonous. The young of some snakes are hatched from eggs; other snakes bear their young alive. Snakes have lungs and breathe as we do. Turtles and alligators are other common reptiles. Amphibians, such as frogs, toads, and salamanders, are cold-blooded. They have skeletons. They differ from other animal groups in that they have gills during the first part of their lives and have lungs later. Amphibians lay eggs.

Birds are warm-blooded. They are the only animals with feathers. They have lungs and well-developed skeletons. All birds lay eggs. Mammals are warm-blooded, also. All mammals have hair on their bodies. All mammals feed their young on milk. Almost all mammals bear their young alive.

WAYS OF PROCEEDING

This chapter is independent of any other. You may want to use the material on cells and protoplasm in Chapter XIII in connection with this chapter.

Introduction and Procedure. This chapter may be introduced by using the picture on page 304 and by playing the game suggested on pages 305–306. Or you may introduce the study of animals by visiting a zoo or a farm or by taking a walk to observe animals. This material involves comparisons. Emphasize the likenesses and differences in animals. Observe animals, use pictures, tell stories, and give reports concerning animals. The animal pictured on page 346 is the platypus, or duckbill. Discuss this animal.

Materials Needed. Large jar, several earthworms.

Something for You (p. 348). 1. Both animals and plants have cells and protoplasm; they reproduce. They need food, light, warmth, and moisture.

2. A good reference book is *Reptiles of the World*, by R. L. Ditmars (Macmillan, New York, 1941).

3. Toads are useful. They eat insects.

4. The feeder should be in a quiet place.

5. Pupils' charts should be filled in like the following:

Animal	Warm-blooded or Cold-blooded	Kind of Skeleton	How It Gets Air	Body Covering	How It Is Born
One-celled Animal	*cold-blooded*	*none*	*through cell wall*	*cell wall*	*cell divides*
Worm	*cold-blooded*	*none*	*through skin*	*skin*	*from eggs*
Reptile	*cold-blooded*	*simple*	*lungs*	*scales*	*eggs or alive*
Fish	*cold-blooded*	*simple*	*gills*	*scales or skin*	*eggs or alive*
Amphibian	*cold-blooded*	*well developed*	*gills lungs*	*skin*	*eggs*
Bird	*warm-blooded*	*well developed*	*lungs*	*feathers*	*eggs*
Mammal	*warm-blooded*	*well developed*	*lungs*	*hair or fur*	*eggs or alive*

Further Activities. Build a balanced aquarium. Full instructions are given on pages 254–256 of Craig's *Science for the Elementary-School Teacher*. Keep animals in the classroom in proper homes and observe them.

Evaluation. Use the chart for a subject-matter test. Play the game on pages 305–306 again. Evaluate research and reports.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

amoeba (*ȧ* mē′b*ȧ*). A one-celled animal.

amphibian (ăm fĭb′ĭ *ă*n). A group of animals having a backbone and which get air from the water during the first part of their lives. Later these animals have lungs and get air as we do. Frogs and toads are amphibians.

cold-blooded animal. An animal whose blood is about the same temperature as the water or air around it. Snakes, frogs, and fish are cold-blooded animals.

fang (făng). A long, sharp tooth by which an animal seizes and holds its prey; especially one of the hollow or grooved teeth of a poisonous snake.

gill (gĭl). The part of the body of some water-living animals which is used to take in air under water.

larva (lär'vȧ). The wormlike form in which certain insects hatch from the egg and in which they remain until they form a chrysalis or cocoon. A caterpillar is a larva.

mammal (măm'ăl). Any animal whose young is fed milk from its mother's body.

paramecium (păr ȧ mē'shĭ ŭm). A one-celled animal.

platypus (plăt'ĭ pŭs). A mammal that lays eggs and has a bill like that of a duck. It is also known as the duckbill.

reptile (rĕp'tĭl). A cold-blooded animal with scales or a scalelike covering, which breathes with the use of lungs all its life.

sea anemone (ȧ nĕm'ō nē). A sea animal resembling a flower.

sea urchin (ûr'chĭn). A spiny sea animal resembling a plant.

warm-blooded animal. An animal whose blood remains at a certain temperature. Dogs, cats, cows, and birds are warm-blooded animals.

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FILMS

Shep—The Farm Dog
Snapping Turtle
Frog
Pond Insects
Beach and Sea Animals
Sunfish
How Nature Protects Animals
Care of Pets
Thrushes and Relatives
Animal Life

XV. PEOPLE ARE PLANNERS

MEANINGS FOR CHILDREN

Man is a mammal, but he is different from all other mammals in that he is able to think and plan. People, like all animals, are dependent on green plants and other animals for food. People need warmth, sunlight, food, and water for proper growth. Because people can plan, they can do many things. They can plan for the protection of plants and animals. They can plan healthful places to live in. Most important of all, they can plan to live well together.

YOU MAY NEED TO KNOW

Man is quite similar to other mammals in bodily structure. He is very different in that he is able to think and plan. This ability of his has not always been used in the wisest way or to the fullest extent. One of the first things we need to understand is that all races of men are fundamentally alike. They are all able to think and plan. The thinking ability of some people is greater than that of others, but all can plan and work together.

You will find evidence of planning all around you. People plan meals, vacations, work. Some groups of people are very much interested in plant and animal conservation. Write your national and state governments for free material on plant and animal conservation. Understanding of a subject is the first step in co-operation. Mineral resources, such as oil, gas, and coal, also must be conserved. Perhaps, most of all, we are interested in human conservation. We are interested in proper food, housing, and clothing. We want to live in a peaceful world. All this takes planning and the active co-operation of all the people.

WAYS OF PROCEEDING

This chapter may be used independently or following Chapter XIV, "Knowing Animals."

Introduction and Procedure. You may have this chapter follow Chapter XIV, or you may introduce it by asking "Which animals

are we most like?" Or you may read with your children pages 351–355.

The main theme is conservation. In addition to the conservation ideas set forth in this chapter, you will want to obtain materials from your national, state, and local governments concerning conservation. Much of such material is free; some pamphlets are priced very low. Write and ask for a list of printed materials. The Department of the Interior at Washington, D. C., has fine material on soil conservation, forest conservation, dams, good farming practices, and so on.

Many communities are engaged in planning for better housing, play space, transportation, and educational facilities. Get in touch with your local authorities to find out about plans which are being made in your community for these things.

Children should become aware that planning is going on. They need to learn about what is happening in the larger community. At the same time, they can work and plan in their school community. Plan with them concerning their health habits. Let them assume responsibility for the proper lighting and ventilation of the classroom. Let them help you to plan a part or all of the day's work. Help them to become conscious of the appearance of the school building and grounds.

Something for You (p. 369). 1 and 2. Use a committee.

3. We need good food, adequate play, fresh air, sunshine, and rest.

4. Use government pamphlets on this too.

5. You may be able to get a film if a visit is not possible.

6. Use a committee.

7. Fires should be built only in open spaces, on bare ground or rocks, and preferably near water. A fire should be thoroughly put out with soil or water. Not a single live spark should be left. Matches should be thoroughly put out, not tossed away while burning.

8. Have a lively discussion. Make a chart or mural showing ways of working together.

Further Activities. 1. From information obtained locally or in

government pamphlets, set up a model farm. Use a large shallow box filled with earth. Show contour plowing and check dams. Make buildings of paper. Sow corn and grass for plants. Use tree seedlings for trees.

2. Build a model city with light, airy houses, good transportation and shopping facilities, churches, and adequate school and recreation facilities.

Evaluation. Use the class-discussion type of evaluation. Let children evaluate themselves as to their health habits, their co-operation, and so on. Self-evaluation is a real part of planning. Help your children to grow toward effective self-evaluation.

IMPORTANT SCIENCE WORDS IN THIS CHAPTER

game warden (wôr′d′n). A person who sees to it that laws relating to hunting and fishing are obeyed.

open season. A period of time during which certain animals may be hunted.

reservation (rĕz ẽr vā′shŭn). An area of public land set aside for a special use, such as recreation, hunting, and the like.

sanctuary (săngk′tū̑ ẽr ĭ). A place especially set aside for animals.

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FILMS

Conservation of Natural Resources

Arteries of the City*

Defending the City's Health*

*Films so designated are somewhat advanced in comparison with the text, but may be useful for some groups.

Care of Animals in the Classroom

Aquarium. The aquarium should be scoured with clean sand and water. Do not use soap or a cleanser, as it is almost impossible to rinse the aquarium thoroughly. Wash small gravel or sand through several waters and place it in the aquarium to a depth of about $1\frac{1}{2}$ inches. Gather water plants from a stream or pond, or buy them at a pet store. Wash the plants thoroughly, and plant them in the sand. Be sure they are well anchored. Lay a large sheet of clean white paper over the plants and pour water onto the paper. The paper keeps the plants and sand from being disturbed. Fill the aquarium to within $\frac{1}{2}$ inch of the top. Place a glass cover on the aquarium to keep dirt out of the water. Let the water stand for at least twenty-four hours before putting in fish and snails. Allow "one inch of fish" for each gallon of water in the aquarium. Do not overfeed your fish. Remove uneaten food from the aquarium. Do not put shells or "fish houses" in the aquarium, as they hide uneaten food.

If your fish are tropical, the water must be kept at a higher temperature than if you keep goldfish. Room temperature is suitable for goldfish. The water in a tropical-fish aquarium should not go below 68° F. You will probably have to use an aquarium heater or an electric bulb to heat a tropical-fish aquarium.

See *Science for the Elementary-School Teacher*, pp. 254–258, for more complete information on aquaria and terraria.

Food for Animals. *Caterpillars.* Leaves on which caterpillars naturally feed. Milkweed leaves for monarch-butterfly caterpillars; apple leaves for Cecropia-moth caterpillars. The leaves should be fresh.

Fish. Prepared fish food, chopped mealworms, shredded raw beef, chopped earthworms, yolk of hard-boiled egg. (Use small amounts.)

Frogs and toads. Live food, swatted flies, and other insects.

Snails. Algae on side of aquarium and aquarium plants are natural food. In addition, use food given to fish.

Tadpoles. Shredded boiled lettuce or algae in pond water.

Turtles. Chopped raw meat, overripe fruit (especially bananas), hard-boiled egg, mealworms, chopped earthworms, lettuce. Always break food into small pieces and put food in water, as turtles feed in water.

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Materials Needed

Many of the following materials may be secured from home, at school, or from your community stores. If some of the items are not available locally, they may be secured from one of the scientific-supply houses listed below.

Aquarium with cover
Balloons
Bar magnet
Blocks
Blotters
Bottle (Pyrex nursing)
Bottles (quart)
Bowls (for bulbs)
Boxes (shallow wooden)
Brown paper (for murals)
Bulbs (narcissus and onion)
Cages for animals
Candles (large and birt ay)
Chalk
Compass
Cups (paper)
Dish (Pyr

Dry cells (1 or 2)
Electric hot plate
Fish for aquarium
Flashlight bulbs
Flashlight-bulb sockets

Metal rod (thin)
Mirror (pocket)
Nails (large)
Pan or dish (shallow)
Paraffin or wax
Plants for aquarium
Pl classroom

Seeds (corn, bea , etc.)
Snails aquarium
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APPLETON. D. A ... 2d St., New York, N. Y.

DEVIN-ADAIR. T ... St., New York 10, N. Y.

DODD. Dodd, Me ... York, N. Y.

DONOHUE. M. A. ... St., Chicago 5, Ill.

DUTTON. E. P. Dutton & Co., Inc., 300 Fourth Ave., New York, N. Y.

GINN. Ginn and Company, Statler Building, Park Square, Boston 17, Mass.

HARCOURT. Harcourt, Brace and Company, 383 Madison Ave., New York, N.Y.

HARPER. Harper & Brothers, 49 East 33d St., New York, N. Y.

HOUGHTON. Houghton Mifflin Company, 2 Park St., Boston, Mass.

INTERNATIONAL. International Textbook Company, 1001 Wyoming Ave., Scranton 9, Pa.

JOHNSON. Johnson Publishing Company, 8-10 South 5th St., Richmond 12, Va.

KNOPF. Alfred A. Knopf, Inc., 501 Madison Ave., New York 22, N. Y.

LIPPINCOTT. J. B. Lippincott Company, 227-231 South 6th St., Philadelphia 5, Pa.

LITTLE. Little, Brown and Company, 34 Beacon St., Boston 6, Mass.

MCGRAW. McGraw-Hill Book Company, Inc., 330 West 42d St., New York 18, N. Y.

MACMILLAN. The Macmillan Company, 60 Fifth Ave., New York, N. Y.

MORROW. William Morrow & Company, Inc., 425 Fourth Ave., New York 16, N. Y.

PRENTICE-HALL. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y.

PUTNAM. G. P. Putnam's Sons, 2 West 45th St., New York, N. Y.

RANDOM. Random House, Inc., 2 ...

REYNAL. Reynal & Hitchcock, 8 ...

ROW. Row, Peterson & Co., 1911 ...

SCRIBNER. Charles Scribner's Sons, 597 Fifth Ave., New York, N. Y.

SINGER. L. W. Singer Company, 249-259 West Erie Blvd., Syracuse, N. Y.

TEACHERS COLLEGE, COLUMBIA. Teachers College, Columbia University, 525 West 120th St., New York 27, N. Y.

UNIVERSITY OF CHICAGO. The University of Chicago Press, 5750 Ellis Ave., Chicago, Ill.

VANGUARD. Vanguard Press, Inc., 424 Madison Ave., New York 17, N. Y.

VAN NOSTRAND. D. Van Nostrand Company, Inc., 250 Fourth Ave., New York 3, N. Y.

WHITTLESEY. Whittlesey House. McGraw-Hill Book Company, Inc., 330 West 42d St., New York 18, N. Y.